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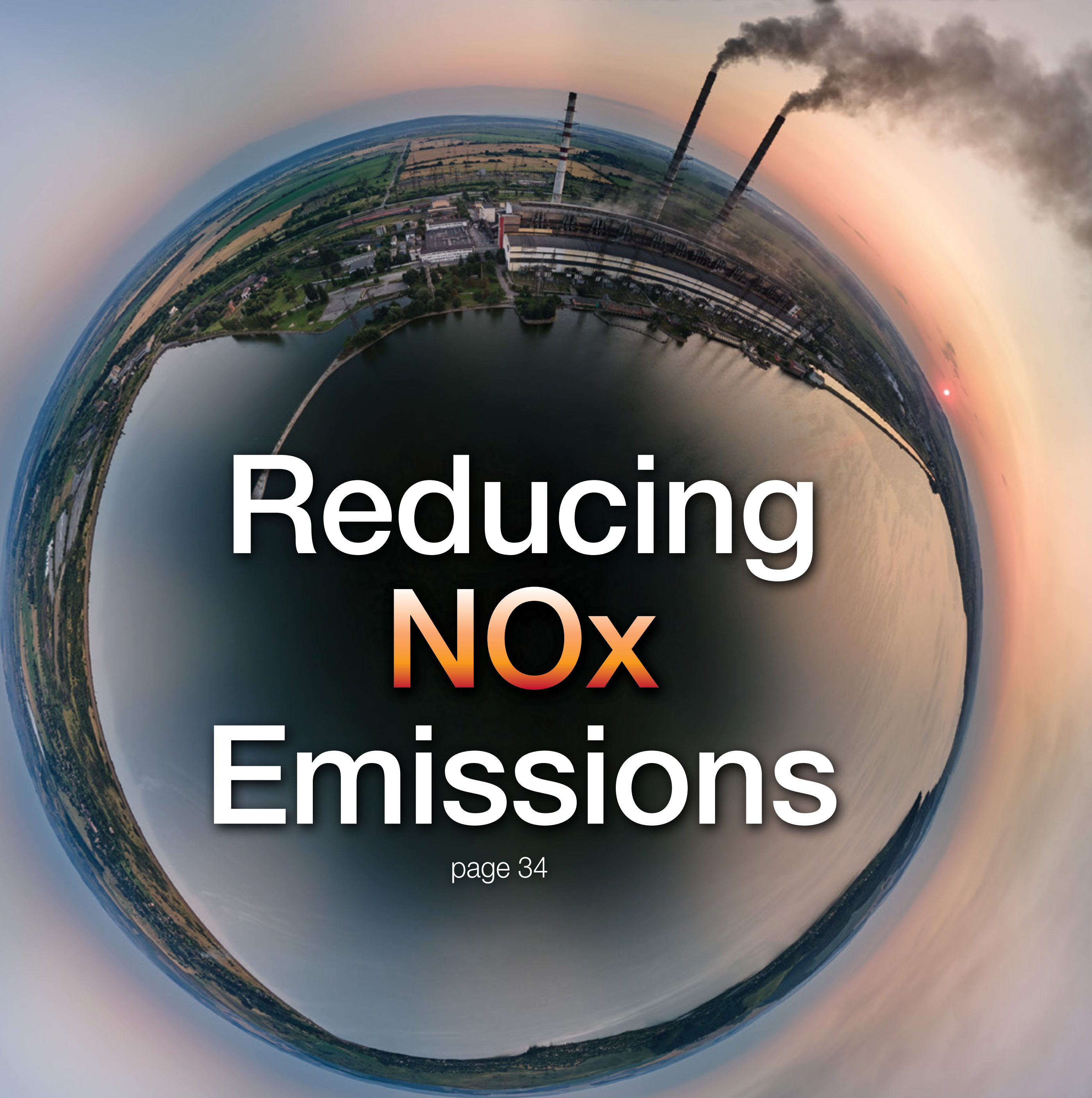

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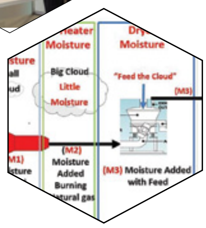

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Cover design:
Tara Bekman

Editor's Page

A chemical industry profile

Last month, the American Chemistry Council (ACC; www.acc.org) released its 2022 edition of the "Guide to the Business of Chemistry [*1*]," which profiles the U.S. chemical industry, including markets, developments, contributions to both domestic and global economies and more. The report reminds us how ubiquitous the products of the chemical process industries are in our everyday lives.

Everyday chemistry

Products manufactured by the chemical process industries are used in most of the items that surround us in our modern world. The importance of some of these products was highlighted by the coronavirus pandemic, when hand sanitizers, disinfectants and personal protective equipment were in very high demand. But contributions of chemistry to healthcare are much broader and found in home and hospital medical supplies, such as in tubing, sutures, bandages, IV (intravenous) bags, instruments and equipment, as well as in pharmaceuticals.

Chemistry also plays an important role in our everyday electronic devices in components such as touchscreens and batteries. Plastics allow for versatile and lightweight products for everything from smart phones to our automobiles. In fact the increased demand for electric vehicles has been driving the demand for high-performance polymers [*2*].

In the energy sector, increased implementation of renewable energy sources requires solar panels that rely on silicon-based chemistry. Battery developments are ongoing. And efforts to improve energy efficiency make use of chemistry, for example in new lighting sources and home insulation products.

Chemical products are also used in just about every facet of building and construction, including cement, roofing and siding, as well as interior elements like flooring and countertops.

Developments in chemistry contribute to sustainability goals in decarbonization, recycling efforts, water conservation and other environmental challenges. See, for example, winners of the "Green" Chemistry Challenge [*3*].

Economics

With the wide variety of products from the chemical industry, the ACC reports that it is one of America's largest manufacturing industries — "a $517 billion enterprise providing 537,000 skilled, high-paying jobs." It is also one of the world's largest exporters, responsible for 10% of all U.S. goods exported in 2021 at $151 billion. The industry also spent over $30 billion in capital investments last year.

Chemical companies typically invest about 2–3% of their annual sales in research and development (R&D), and some companies invest at a significantly higher rate. In 2021, R&D investments were $11.4 billion.

Many more details about the categories of production, markets and economics can be found in the ACC report [*1*]. ■

Dorothy Lozowski, Editorial Director

1. The 2022 Guide to the Business of Chemistry is prepared by the ACC's Economics and Statistics Department and can be found on its website (www.acc.org).

2. Electric Vehicles Drive Performance Polymers, *Chem. Eng.*, pp. 14–16, August 2021.

3. The 'Green' Chemistry Challenge, *Chem. Eng.*, p. 4, July 2022.

Extracting pressurized hydrogen from ammonia, methane and biogas

Proton ceramic cells that couple endothermic steam reforming with heat from electrochemical gas separation and compression have been scaled up. These cells, developed by CoorsTek Membrane Sciences AS (Oslo; www.coorstek.com), the University of Oslo (both Norway; www.uio.no) and the Institute of Chemical Technology (Valencia, Spain; http://itq.upv-csic.es), were first demonstrated at laboratory-scale (*Chem. Eng.*, January 2018, p. 5). Since then, the researchers have developed a way to couple 36 cells together in a proton ceramic electrochemical reactor (PCER; photo) such that the energy efficiency and H_2 recovery is the same as that of a single cell, while achieving a 36-fold increase in H_2 production capacity. The performance was demonstrated in collaboration with scientists from SINTEF (Oslo, Norway; www.sintef.no).

Described in a recent issue of *Science*, the scaleup was achieved by using 3D multiphysics simulations that integrated coupled gas flows, heat transfer, current distribution and reaction kinetics for steam-methane reforming (SMR) and water-gas shift (WGS) reactions and ammonia dehydrogenation (ADH). On the hardware side, a new expansion-matched metal/glass-ceramic composite interconnect (IC) was developed to couple multiple proton ceramic cells together into an optimized system.


CoorsTek Membrane Sciences

In tests, the 36-cell PCER has achieved a nearly full conversion of CH_4 and high (>99%) H_2 recoveries from CH_4 and biogas, while producing a CO_2-rich stream suitable for carbon capture, says lead author Daniel Clark, senior scientist and project manager at CoorsTek. The PCER produces 0.4 kg/d of H_2. The PCER also achieves a near 100% conversion of NH_3 with high H_2 recoveries, he says.

A pilot facility that is five-times larger (five PCERs connected together) is now installed and operating at Saudi Aramco's headquarters in Dhahran, Saudi Arabia. The next module size for scaling up is planned to be 250 kg/d of H_2, and will form the basis for early H_2-fueling stations of 1 ton/d, says Clark. CoorsTek Membrane Sciences envisions the first industrial installation of a commercial system in the next 2–3 years. The research is being funded by ENGIE, ExxonMobil, Equinor, Saudi Aramco, Shell and Total Energies, as well as by Gassnova as part of the CLIMIT CO_2 management research program.

Zero-CO_2 ethane cracker technology is available commercially

A next-generation ethane-feed steam cracker designed by Lummus Technology (Houston; www.lummus.com) has the ability to achieve zero carbon dioxide emissions in the production of ethylene. The zero-CO_2 design utilizes Lummus SRT pyrolysis furnaces and a state-of-the-art product-recovery system. Lummus improved these features to reduce the firing requirements in the pyrolysis furnaces and to enhance the recovery of hydrogen such that the combustion of hydrocarbon fuel is eliminated.

The combustion of methane or other carbon-based fuels can be eliminated through innovations to the cracking heater design, resulting in significant reductions in the fuel firing demand, as well as enhancements in the recovery section and a partial switch from steam turbine to electric drivers on the major compressors.

The design is very flexible, to allow for differences in specific site conditions, and is based on fully demonstrated technology, reconfigured for the sole purpose of CO_2 elimination, explains Jose de Barros, who leads Lummus' ethylene business.

"The zero-CO_2 cracker is less the invention of new technologies, and more a complete rethinking of all the elements of conventional steam cracker to allow it to operate without generating CO_2," says Leon de Bruyn, president and CEO of Lummus. Lummus has filed a patent on the cracker technology, which is said to be the first of its kind in industry. It is now available for commercial use and can be incorporated into both new and existing ethane crackers, and at sites and facilities of different sizes, de Bruyn says.

Edited by:
Gerald Ondrey

ZERO-SPIN SILICON

Natural silicon consists of three isotopes: ^{28}Si (92.2%) and ^{30}Si (3.1%) — each with zero electron spin state — and ^{29}Si (4.7%) with a spin state of one half. The presence of ^{29}Si in concentrations above 500 parts per million (ppm) (0.05%) prevents effective quantum computing (QC) performance, so zero-spin Si (ZS-Si) must be produced by elimination of the ^{29}Si isotope. The lower the concentration of ^{29}Si, the better a silicon quantum processor will perform in terms of computational power, accuracy and reliability. However, current methods for production of enriched silicon are limited and costly, with only a few kilograms produced annually, mostly using gas centrifuge technology.

Now, Australians are a step closer to demonstrating an alternative process to produce ZS-Si. A pilot demonstration facility has been constructed to demonstrate the commercial production capability for high-purity ZS-Si. The plant, part of the ZS-Si project, is based on a variant of the laser isotope-separation (LIS) process of Silex Systems Ltd. (Lucas Heights, NSW, Australia; www.silex.com.au). Initial production tests are planned to start in 2023.

ENZYMES

Microbiologists at Goethe University Frankfurt (GUF; Frankfurt am Main, Germany; www.bio.uni-frankfurt.de), together with researchers from the universities of Marburg (www.uni-marburg.de) and Basel (Switzerland; www.unibas.ch), have shed light on the structure of an enzyme that produces formic acid from H_2 and CO_2. The enzyme of the bacterium *Thermoanaerobacter kivui* was discovered a few years previously by microbiologists at GUF, and the scientists have recently presented its potential for liquid H_2 storage. As reported in a recent

(Continues on p. 6)

issue of *Nature*, the filamentous structure of the enzyme, now described at atomic level for the first time, acts like a nanowire and is evidently responsible for the extremely efficient conversion rates of the two gases.

The structure reveals why the hydrogen-dependent CO_2 reductase (HDCR) enzyme is orders of magnitude more efficient than all chemical catalysts and far better than all known enzymes at producing formic acid as a liquid-organic-hydrogen carrier from H_2 and CO_2. "The hydrogen concentrations in the ecosystem of these bacteria are low, and, in addition, the CO_2 and H_2 concentrations can switch. Formation of filaments and bundling not only substantially increase the concentration of these enzymes in the cell. The thousands of electron-conducting iron atoms in this 'nanowire' can also store the electrons from hydrogen oxidation intermediately when even just one hydrogen bubble passes by the bacteria," explains professor Volker Müller, head GUF's Dept. of Molecular Microbiology and Bioenergetics.

WASTE-TO-H_2

Raven SR (Pinedale, Wyo; www.ravensr.com) plans to use INNIO's (Jenbach, Austria; www.innio.com) Jenbacher engines [60 Hz] with a "Ready for H_2" option to produce renewable energy. The energy system will power and heat Raven SR's S-Series H_2-production facility at a sanitary landfill in Richmond, Calif. At the site, landfill gas (LFG) will be the primary fuel to provide power for the non-combustion process that converts waste to H_2. The H_2 product will be resold to power fuel cells in heavy-duty trucks. The Raven SR process will also provide a residual fuel contain-

(Continues on p. 8)

Energy costs cut by 50% for high-strength aluminum alloys

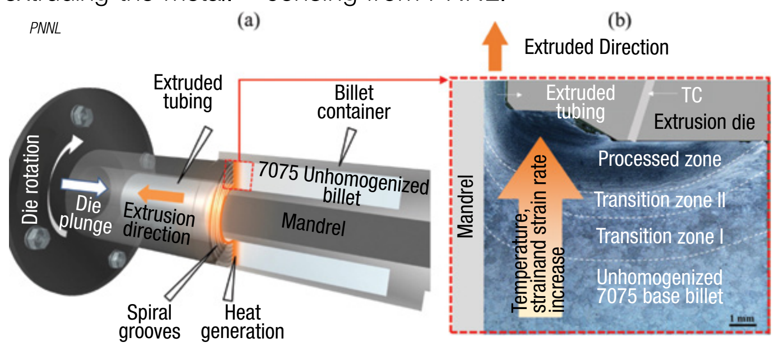
Aluminum alloy 7075 has excellent mechanical properties, including high strength for lightweighting applications, but its production process is energy intensive, which raises costs and limits its use. Now, scientists at Pacific Northwest National Laboratory (PNNL; Richland, Wash.; www.pnnl.gov) have developed a process for making the alloy that eliminates the major energy-consuming step in conventional production: homogenization. Eliminating this heat-treatment step reduces the energy required for the overall production by half.

In conventional production of Al 7075, homogenization involves heating castings of the metal to around 500°C for up to 24 hours to dissolve intragranular secondary phases of alloying elements (aluminum, zinc, magnesium, copper) before extruding the metal. The PNNL team developed a process, known as shear-assisted processing and extrusion (ShAPE), that combines heating and physical deformation of the metals, so that a separate homogenization step is not required.

In the ShAPE machine, metal billets are simultaneously pushed through a small opening in a die that rotates. Together, the rotational movement and deformation thoroughly mixes the metal elements as they are being extruded, PNNL says, essentially, homogenizing the metal billet in a few seconds immediately before it is extruded.

Using ShAPE results in energy savings of up to 50%, PNNL scientists say, and also improves the quality of the mixing of the individual alloying elements, which leads to stronger final products.

A study published in a recent issue of *Materials and Design* reports electron microscope images of the alloy's microstructure that show the effectiveness of the ShAPE process at mixing the alloy elements. The technology is available for licensing from PNNL.



Print the filter shape needed

An adaptable sintered filter element that is manufactured by 3D printing will be introduced this month at the Powtech exhibition (September 27–29; Nuremberg, Germany; see also pp. 29–30). Developed by Herding GmbH Filtertechnik (Amberg, Germany; www.herding.com), Omikron is an adaptable sinter-plate filter element that can be tailor made to the desired size and shape (photo), in quantities as low as a single element.

Up to now, the company's conventional sinter-plate filters have been focused on a linear lamella geometry. Although these elements are available in a wide variety of dimensions, there had been no change to the linearity of the basic geometry determined by the sinter shape. The new Omikron filter element eliminates the geometric limitations of standardized shapes, and, for the first time, makes it possible to adapt geometries to the intended use and structural conditions.

Smaller sizes are also possible. Before the introduction of Omikron, Herding's smallest filter element had a filtration area of 0.7 m^2, but thanks to the new production process, significantly smaller filter elements can now be manufactured, which is beneficial for biotechnology applications.

Both the basic body and the coating of the filter elements are produced from polyethylene (PE), and the filter element complies with V(EG) 1935/2004, VO(EU) 10/2011, as well as U.S. Food and Drug Admin. (FDA) requirements for applications in the food and pharmaceutical sectors. Further product-specific features are the possibilities to wash and sterilize the filter element according to industrial standards, the company says.

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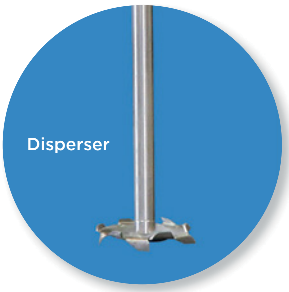

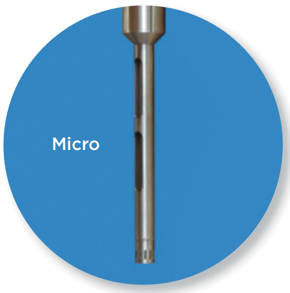

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ing residual “green” H_2 from the concentration process to supplement the LFG to fuel the Jenbacher Ready-for-H_2 engines to generate renewable power in a continuous loop.

The collaboration with Raven’s technology offers a strong alternative to electrolysis: less electricity is used and fresh water is not needed. INNIO’s Jenbacher engines will allow the Raven facility to generate a significant amount of its own electricity.

Raven SR plans to bring its S-Series online in the first quarter of 2023 at the Republic Services West Contra Costa Sanitary Landfill in Richmond. This project will initially process up to 99.9 ton/d of organic waste and produce up to 2,000 metric tons per year of H_2.

PFC ABSORBANT

Because polyfluorinated carbons (PFCs) are chemically highly stable, they accumulate in the atmosphere and stay there for several thousands of years before breaking down. As a result, PFCs have a much greater global warming potential (5,000–10,000 times) than CO_2.

To capture such compounds, researchers at the Institute of Organic Chemistry of Heidelberg University (Germany; www.uni-heidelberg.de), led by professor Michael Mastalerz, have developed new crystalline materials that can selectively adsorb PFCs. The porous crystals are based on shape-persistent organic-cage compounds that carry fluorine-containing side chains on the interconnected struts. These side chains react according to the “like attracts like” principle via fluorine-fluorine interactions with the PFC molecules, ensuring they are deposited on the inner surface of the material.

In laboratory experiments, the researchers demonstrated that the crystals they developed bind certain fluorine-containing gases approximately 1,500 to 4,000 times more strongly

(Continues on p. 9)

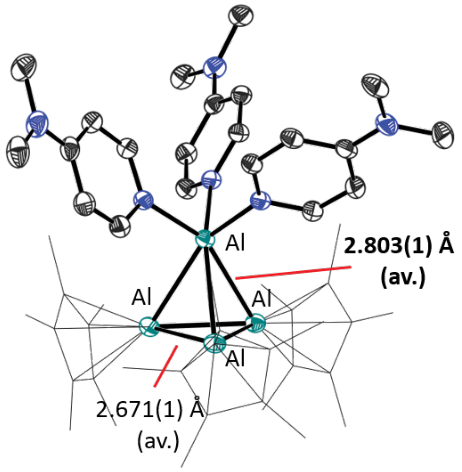
A step closer to transition-metal catalysis with aluminum

Chemists from the Institute of Inorganic and Analytical Chemistry at the University of Freiburg (Germany; uni-freiburg.de) have synthesized a cationic, low-valence aluminum complex salt. “So far, there has been only one example of a cationic, low-valent aluminum compound, but it cannot be prepared by rational synthesis,” says professor Ingo Krossing. “We now show that there is an unexpectedly easy access to low-valent aluminum complexes with metathesis after all,” he says.

“In chemistry, cationic low-valent aluminum compounds are highly sought after due to their potential transition-metal-like ambiphilic reactivity. However, numerous previous attempts to synthesize cationic low-valent aluminum compounds by oxidative or reductive methods have been largely unsuccessful,” Krossing explains.

Together with Philipp Dabringhaus and Julie Willrett, Krossing described their achievement in a recent issue of *Nature Chemistry*. The Freiburg chemists prepared the salt $[Al(AlCp^*)_3]^+[Al(OC\{CF_3\}_3)_4]^-$ from the Schnöckel tetramer $(AlCp^*)_4$, in which aluminum is already present in the +1 oxidation state ($Cp^* = [C_5Me_5]^-$). The $(AlCp^*)_4$ reacted with $Li[Al\{OC(CF_3)_3\}_4]$ and the reaction mixture immediately turned from yellow to red. When the reaction mixture was crystallized, the scientists obtained the

University of Freiburg



$[Al(AlCp^*)_3]^+[Al(OC\{CF_3\}_3)_4]^-$ salt as dark purple crystals.

“This salt can potentially be used as a building block for an $[:Al(L)_3]^+$-salt that, due to its cationic nature, might be able to perform reversible oxidative additions and reductive eliminations of small molecules,” Krossing explains (L = a ligand, such as dimethylaminopyridine, as shown in diagram). “This brings us one step closer to our long-term goal of achieving catalysis — currently done with expensive and rare transition metals — with aluminum,” he says. “But unfortunately, it will probably be at least another 20 years before our research on this is applied.”

This particle sensor exploits quantum effects for real-time process optimization

Last month at Achema 2022 (August 22–26; Frankfurt am Main, Germany), Q.ANT GmbH (Stuttgart, Germany; www.qant.de) introduced what is said to be the world’s first industrial-grade quantum sensor for particle analysis. By the use of super-fast software, electronics and artificial intelligence (AI), the parameters are determined and classify the particles according to their shape.

According to the patent for the sensor, which was issued in June (U.S. 113 71 928), a diode laser is passed through a mode converter that generates a field distribution of the laser beam, where each position has a different combination of local intensity and polarization. This field distribution is focused to a plane through which the sample passes, and then enters a receiver that analyzes the polarization-dependent intensity of the field distribution after it passes through the sample. With this information, it is possible to determine the particle’s position, velocity acceleration and size. Together with AI, which requires training for a given application, the signals can be classified according to the desired specifications. The company is building up a database of use cases in order to draw on information already gained to shorten the training of the AI.

Because the sensor measurement is very fast, the new device can be used for process control in real-time. It is suitable for particles in different gases, as well as in liquids or powders. The company is developing a complete laboratory-scale instrument, also available as an ATEX version. It also offers OEM sensors that can then be adapted for specific applications. Q.ANT is already working with Festo SE & Co. KG (Esslingen am Neckar, Germany) to develop applications for monitoring and controlling algae growth, as well as with SICK AG (Waldkirch, Germany) for developing specific particle analyzers.

A new electrolyte supercharges sodium-ion batteries

Sodium-ion batteries have many advantages over lithium-ion batteries due to sodium's abundance and low cost. However, there are several performance challenges to overcome with sodium-ion batteries because there is typically a tradeoff between energy density and lifecycle. Now, a research team from Pacific Northwest National Laboratory (PNNL; Richland, Wash.; www.pnnl.gov) has discovered an enhanced battery chemistry that extends the lifecycle of sodium-ion batteries while also reducing their safety hazard. Led by Ji-Guang (Jason) Zhang, laboratory fellow at PNNL, the research focused on the battery's solid-electrolyte interface (SEI), which is a barrier layer that protects the anode. "One of the main challenges for high-energy sodium-ion batteries is the dissolution of the anode SEI, especially when a high-voltage cathode is used. Our new electrolyte largely reduces the degradation of the SEI layer, so the battery maintains a much longer lifecycle at high voltages," explains Zhang.

The electrolyte was designed with a solvent with low-dielectric constant (tris 2,2,2-trifluoroethyl phosphate [TFP]), which has a low solvability for the SEI layer, and an electrolyte salt (NaFSI) that promotes the formation of a stronger protection layer. Laboratory tests demonstrated that the new design retained 90% of its cell capacity after 300 cycles at 4.2 V, which is notably higher than most sodium-ion batteries.

Furthermore, the new design offers improved safety features. "TFP, the main solvent of the electrolyte, is a fire-extinguishing organic solvent, which largely reduces the potential risks of fire hazards," adds Zhang, noting that work is still underway to verify the safety of larger-scale batteries. The next development step will be further improving the cycle life of the batteries and scale up from small coin cells to larger pouch cells, which the team expects will attract more commercial interest in the batteries.

than N_2. According to Mastalerz, these numbers represent "extraordinarily high" selectivities to bind such PFCs. The study was described in a recent issue of *Advanced Materials*.

BIOCATALYSIS

Aa major challenge in biocatalysis is that the most commonly used microbes, such as probiotics and non-pathogenic strains of *Escherichia coli*, are not necessarily good at forming biofilms, the growth-promoting ecosystems that form a protective micro-environment around communities of microbes and increase their resilience and so boost productivity. This problem is normally solved by genetic engineering, but researchers from the University of Birmingham (U.K.; www.bham.ac.uk) have found an alternative method to bypass this costly and time-consuming process.

As described in a recent issue of *Materials Horizons*, the researchers screened a library of synthetic polymers for their

(Continues on p. 10)

ability to induce biofilm formation in *E. coli*. This screening used a strain of *E. coli* (MC4100) that is widely used to study genes and proteins and is known to be poor at forming biofilms, and compared it to another *E. coli* strain (PHL644), an isogenic strain obtained through evolution that is a good biofilm former. This screening revealed the chemistries that are best suited to stimulating biofilm formation.

The researchers then monitored the biomass and biocatalytic activity of both strains incubated in the presence of these polymers, and found that MC4100 matched and even outperformed PHL644. Further studies examined how the polymers stimulate these "profound" increases in activity. ❐

Silicate-rock-based material can replace flyash in cement, lowering costs and CO_2

Flyash, a waste byproduct from coal burning, has been used effectively as a supplementary cementitious material (SCM) in Portland cement to displace a portion of the cement and lower the CO_2 emissions associated with cement making. But because coal burning is becoming less common, supplies of flyash are more limited and its quality more variable.

The company Terra CO_2 (Golden, Colo.; www.terraco2.com) has developed a process for making a flyash replacement from silicate-based igneous rock. The product, known as Opus SCM, promises to alleviate issues with flyash supply and lower the costs associated with transporting flyash for cement making.

Opus SCM can be blended into portland cement to displace between 10 and 30% of the cement. Terra CO_2 plans to break ground on the first commercial plant to produce Opus SCM in late 2023.

Manufacturing Opus SCM involves widely available, alluvial and granite-based construction aggregates, which are milled to a size of 6–7 µm. This size is similar to that of the limestone used to make portland cement. The powder is then pneumatically conveyed to a proprietary reactor, where it undergoes air-suspension melting. "We suspend the particles in a flame," explains Bill Yearsley, president and CEO of Terra CO_2. "It's a dust cloud at that particle size, so a good portion of our trade secrets are around what we call 'cloud management.'"

The material "cloud" is melted in milliseconds inside the reactor, resulting in glassy particles that are quenched with ambient air. The resulting reactive microspheres can replace flyash in concrete formulation.

"The materials we use to make Opus SCM are widely available at scale, so they don't require extensive transportation to deliver to concrete makers, and don't require opening new mines," Yearsley points out. The product would be delivered to a silo at a ready-made concrete site, similar to how flyash is currently used.

Using the same manufacturing process, Terra CO_2 plans to introduce a blended cementitious material (BCM) that will be used with an additive at levels of 40% or higher in cement, and eventually, a geopolymer that can be a full replacement for portland cement, Yearsley says. ■

Business News

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Plant Watch

Evonik's Coating Additives business expands production capacity in Taiwan

August 16, 2022 — The Coating Additives business line of Evonik Industries AG (Essen, Germany; www.evonik.com) is expanding production capacity for precipitated matting agents at its manufacturing facility in Taiwan. The capacity expansion is scheduled for completion by the second half of 2023. Evonik also produces matting agents at a site in Bonn, Germany.

Baker Hughes opens new oilfield-chemicals plant in Singapore

August 16, 2022 — Baker Hughes Co. (Houston; www.bakerhughes.com) has opened a new oilfield-services chemicals manufacturing facility in Singapore. The facility, which is the first chemicals site for Baker Hughes in the region, will manufacture, store and distribute chemical solutions for upstream, midstream, downstream and adjacent industries.

SK Geo Centric and Weixing Chemical to construct new EAA plant in China

August 11, 2022 — SK Geo Centric Co. (Seoul, South Korea; eng.skgeocentric.com) plans to establish a new production site in China to produce ethylene acrylic acid (EAA). SK Geo Centric and Weixing Chemical established a joint venture (JV) to invest approximately KRW 290 billion (around $223 million) on the new EAA plant, which is scheduled to be completed in the first half of 2025. The plant will have a capacity of 40,000 metric tons per year (m.t./yr) of EAA.

BASF announces U.S. capacity expansion for specialty pyrrolidones

August 4, 2022 — BASF SE (Ludwigshafen, Germany; www.basf.com) has announced that it will produce more N-(2-hydroxyethyl)-2-pyrrolidone (HEP) and N-octyl-2-pyrrolidone (NOP) at its *Verbund* site in Geismar, La. The expanded production is anticipated to be onstream in the second half of 2022.

Indorama and Capchem considering new plant for LIB solvents in the U.S.

August 1, 2022 — Indorama Ventures Ltd. (IVL; Bangkok, Thailand; www.indoramaventures.com) and Capchem Technology USA Inc. are studying the construction of a world-scale lithium-ion battery (LIB) solvents plant at one of IVL's petrochemical facilities in the U.S. Gulf Coast region. The proposed facility will produce ethylene carbonate and its chemical derivatives, which are components of the electrolyte solutions in LIBs. The key raw materials for the proposed new plant (purified ethylene oxide and carbon dioxide) will be supplied from IVL's integrated supply network.

Mitsubishi Chemical to expand EVOH production capacity in the U.K.

August 1, 2022 — Mitsubishi Chemical Group (MCG; Tokyo; www.mitsubishichem-hd.co.jp) has decided to increase its l production capacity for ethylene vinyl alcohol (EVOH) copolymer resin by 21,000 m.t./yr in the U.K. at MCG's site in Saltend. Once construction begins in April 2023, the production increase, which will bring total EVOH production to 39,000 m.t./yr, is slated to take effect in July 2025.

Chemours to expand production capacity for Opteon YF refrigerant

July 29, 2022 — The Chemours Co. (Wilmington, Del.; www.chemours.com) is investing $80 million to expand production capacity for the Opteon YF (HFO-1234yf) refrigerant at its site in Ingleside, Tex. This investment, along with ongoing de-bottlenecking projects, will increase site capacity by approximately 40%.

Cariflex breaks ground in Singapore for world's largest polyisoprene latex plant

July 28, 2022 — Cariflex Pte. Ltd. (Singapore; www.cariflex.com), a wholly owned subsidiary of DL Chemical Co., broke ground at a site in Jurong Island, Singapore, where the company will be constructing the world's largest polyisoprene latex plant. The full capacity of the Singapore plant will be delivered in two phases. The combined investment for the first phase and pre-investment of necessary infrastructures for the second phase is over $350 million. The plant is expected to be operational by the second half of 2024.

Dow and Al-Hejailan Group to jointly build new MDEA plant in Saudi Arabia

July 27, 2022 — Dow (Midland, Mich.; www.dow.com) and the Al-Hejailan Group signed a Memorandum of Understanding (MoU) to form a JV to design, build and operate a methyl diethanolamine (MDEA) plant in the PlasChem Park in Jubail, Kingdom of Saudi Arabia. The construction of the plant is expected to begin in 2024 and with startup in 2025.

Wacker to build new silicone plant in at Charleston, Tenn. production complex

July 26, 2022 — Wacker Chemie AG (Munich, Germany; www.wacker.com) is preparing to build a new silicone production complex at its Charleston site in Tennessee. In a first phase, it is planned to build plants for high-consistency silicone rubber and silicone sealants, as well as intermediates. In further phases, production plants for other product groups are envisioned, such as silane-terminated polymers, liquid waterproofing systems and wood-flooring adhesives. The capital expenditure for the project is around $200 million.

Mergers & Acquisitions

Solenis to acquire Clearon Corp.

August 11, 2022 — Solenis (Wilmington, Del.; www.solenis.com) entered into a definitive agreement to acquire water-treatment specialist Clearon Corp. Clearon produces trichloroisocyanuric acid (trichlor) and dichloroisocyanuric acid (dichlor) at its South Charleston, W.Va. plant and converts these core chemistries into an array of finished goods at its tableting and packaging facility. Products include sanitizers and disinfectants for water-treatment applications.

BP sells stake in Toledo-based refinery to Cenovus

August 9, 2022 — Bp plc (London; www.bp.com) has reached an agreement to sell its 50% interest in the bp-Husky Toledo Refinery in Ohio to Cenovus Energy Inc., (Calgary, Alta., Canada; www.cenovus.com), its JV partner in the facility. Under the terms of the deal, Cenovus will pay $300 million for bp's stake in the refinery, plus the value of inventory, and will take over operations when the transaction closes, which is expected to occur later in 2022. The refinery can process up to 160,000 barrels per day (bbl/d) of petroleum.

Stratasys to acquire Covestro's additive manufacturing business

Stratasys Ltd. (Eden Prairie, Minn.; www.stratasys.com) will acquire the additive manufacturing materials business of Covestro AG (Leverkusen, Germany; www.covestro.com). The acquisition includes R&D facilities, global development and sales teams, a portfolio of approximately 60 additive manufacturing materials and an extensive patent portfolio. The purchase price is approximately €43 million.

Ube to acquire APIC from Mitsubishi Chemical

August 5, 2022 — Ube Corp. (Tokyo; www.ube.com) will acquire API Corp. (APIC), which is currently wholly owned by Mitsubishi Chemical. APIC is a contract development and manufacturing organization (CDMO) that offers a wide range of services, such as synthetic route design, pilot manufacturing, investigational medical manufacturing and commercial production.

Aramco to acquire Valvoline's Global Products business

August 1, 2022 — Valvoline Inc. (Lexington, Ky.; www.valvoline.com) has reached a definitive agreement with The Saudi Arabian Oil Co. (Aramco; Dhahran; www.aramco.com) for the sale of Valvoline's Global Products business for $2.65 billion in cash. Valvoline Global Products is an independent producer and distributor of lubricants and automotive chemicals. The transaction is targeted to close in late calendar year 2022 or early 2023.

Ineos and Sinopec to jointly build HDPE plants in China

July 28, 2022 — Ineos Ltd. (London, U.K.; www.ineos.com) and Sinopec (Beijing, China; www.sinopecgroup.com) plan to form a 50-50 JV to build a new 500,000-m.t./yr high-density polyethylene (HDPE) plant in Tianjin, China, as well as at least two additional 500,000-m.t./yr HDPE plants in the future to produce pipe-grade products. The Tianjin plant is expected to come onstream by the end of 2023. ■

Mary Page Bailey

Modeling and Simulation:

New Software Capabilities with Digitalization

Latest software combines the best of traditional physics-based and empirical approaches with advanced digitalization technologies

Unless you've had your head buried deep in the sand, you know that digitalization is having an increasing impact on the chemical process industries (CPI). This is particularly true in the modeling and simulation software space. For decades now, steady-state asset modeling and process simulation tools have helped reduce engineering time and effort during the design/build/commission phase of a chemical plant's lifecycle (Figure 1). Dynamic process-simulation models and advanced process-control (APC) algorithms, in turn, have helped optimize both processes and process control in the much longer operational phase. Now, digitalization — and digital twins in particular — are helping provide a common modeling and simulation environment across both phases of the asset lifecycle. Digital twins are also helping to "democratize" the technology, making it more easily accessible, understandable, and useful for a much wider range of personnel.

Architecturally, leading suppliers are developing new solutions that combine the best of traditional first principles and/or empirical approaches with advanced digitalization technologies. Digital twins, which merge the physical and virtual worlds, have also started to take on new roles thanks in part to the incorporation of artificial intelligence (AI), and machine learning (ML) to help train models faster and with less human effort. And when combined with virtual reality (VR) technology, digital twins can now provide plant engineers, operators and maintenance technicians with immersive 3D visualization capabilities for design, operations, maintenance and training (Figure 2). Most of the suppliers interviewed for this article agree that these and other developments help provide a path forward toward a more resilient and sustainable CPI sector that produces more environmentally friendly products, consumes less energy and resources, and releases fewer harmful emissions to our increasingly fragile environment.

Aveva

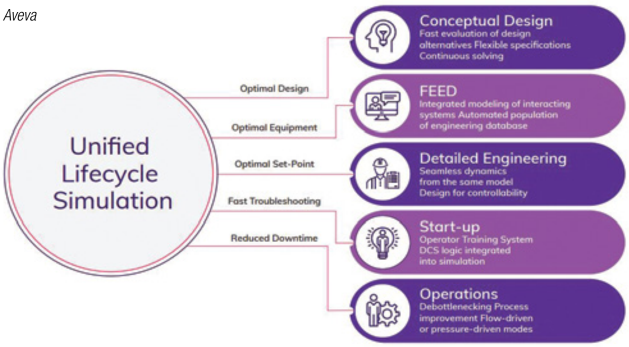


FIGURE 1. Digitalization is helping unify simulation across all phases of the plant lifecycle

First principles meet real data

"As the chemical industry is transitioning from its traditional state toward a circular and environmentally sustainable economy, digital solutions are at the forefront of this transition," according to Ana Khanlari, industry marketing director for Chemicals at Aspen Technology, Inc. (AspenTech; Bedford, Mass.; www.aspentech.com). "Traditional solutions like digital twins are now used for new purposes like reducing emissions or minimizing energy usage. As new processes are becoming complex, there is a need to improve first-principle models with data from operations to increase accuracy."

Elaborating on this, Khanlari explains that hybrid models (Figure 3) can combine first principles of engineering with AI and ML to accurately reflect operations. These models can learn from past performance and control future operations and are particularly helpful when there is a gap in predictions from conventional simulation or a chance of future equipment failure. "Overall, digital solutions ensure productivity, efficiency and reliability while minimizing emissions, energy use, and waste generation," says Khanlari. "New digital solutions allow engineers to represent real plant behavior with models created from first-principles constraints and operational data; capture unknown or immeasurable details of phenomena while recalibrating models to changing process conditions leveraging AI/ML; and create high-fidelity models that can be used for rapid and accurate decisions in engineering and operations or to expand modeling scope," she says.

Digital twins as problem solvers

"Modeling and simulation is the safe, efficient solution for solving real-world problems, says Harpreet Gulati, senior vice president of the Planning & Operations business unit at Aveva Group plc (Cambridge, U.K.; www.aveva.com). "One of the most important digital innovations benefiting the chemical industry is the digi-

FIGURE 2. Virtual reality technology supports 3D visualization of a digital twin

tal twin. The concept of digital twin has been around for nearly a decade but is now having a profound impact across industries," says Gulati. "By aggregating physical, behavioral and process data, digital twins allow chemical facilities to visualize and then extract additional context in never-before-seen granularity. Digital twins enable engineers to design processes and identify the best approach to achieve a quality outcome without increasing the costs.

"Digital twins are the natural solution to continuously optimize equipment and feed-critical data to plant managers," Gulati continues. "Further, plants have been able to reduce unplanned downtime and have achieved ROI [return on investment] more quickly, meaning delays in production do not become delays for the consumer. For companies looking to achieve climate goals and increase visibility, digital-twin technology will be key in enabling educated decision-making. Executing projects and operations on time and budget matters, but companies are facing increasing pressure to also minimize their carbon footprint and environmental impact."

'Best possible' versus 'actual'

According to Russell Byfield, Global Process Simulation leader at KBC (Walton-on-Thames/London, U.K.; www.kbc.global), a Yokogawa Company, the process digital twin is an automated running of a process model that compares the "best possible" with the "actual" to continuously determine opportunities for improvement and to monitor or predict deviations or anomalies early enough before they become expensive problems. But integrating simulation with ML/AI is not a "magic wand," he warns. "Knowing which mathematical approach is best applied to solve which problem is the fastest route to a reliable solution," he says.

"ML, for example, provides benefits in specific nonlinear, highly mathematical situations that require rapid calculations," Byfield explains. "Since, by definition, a digital twin is fully automated, it can run itself, either on a scheduled or when-needed basis. This automation also saves engineering time, enabling engineers to spend more time solving actual process or operational problems, rather than just trying to identify problems. Digital twins, in general, provide permanent, continuous tools enabling chemical processing plants to drive toward more reliable and, ultimately, optimal operation," he says.

Real-time corrective actions

Vineeth Ram, chief revenue officer at OLI Systems (Parsippany N.J., www.olisystems.com), elaborates on how current simulation solutions can provide significant benefits across the lifecycle of an asset. "Process modeling software has moved from being a simple design or simulation tool to being part of the daily operation/optimization of a chemical plant. Operations measures its success in various ways. However, there are areas where instrumentation is impractical. Process simulation can now provide calculated parameters, or "soft sensors," which are useful to create a set of diverse indicators and influence decision making for areas that cannot be directly monitored," says Ram.

"In addition to the core simulation technology development, the ability to deliver process simulation insights anywhere, anytime to any software application or end user by leveraging cloud platforms and state-of-the-art data integration capabilities is accelerating digital transformation of these organizations," Ram continues. "They can now use real-time monitoring and automation to provide digital twins of their operations and take corrective actions in real time."

Determining a model's value

"At its core, a process model is a digital twin," according to Steve Brown, president of Chemstations, Inc. (Houston; www.chemstations.com). "The level of detail and fidelity used by the engineer(s) to build the model determines the value of the resultant model. By that I mean that a quick and dirty model will often return qualitative results that can be valuable at various phases of either design or operation of a facility, while a very detailed and rigorous model can provide quantitative results that can be integrated into SCADA/HMI displays, business-level decision-making, or even operator training." Brown also points out that performance still counts and new multicore processing capabilities enable

END USERS CALL FOR OPEN AND SUSTAINABLE DIGITAL TWINS

In a recent development of note, a group of subject matter experts from several leading global energy and chemical industry companies created the Sustainable Asset Digital Twin Working Group to discuss common needs and provide guidance to the vendor community. (Note: This working group, composed largely of process industries end users, is not related to the various working groups previously established by the Object Management Groups' Digital Twin Consortium, which has a somewhat different focus and membership.)

According to an April 2022 ARC Advisory Group (Dedham, Mass., www.arcweb.com) report, the Sustainable Asset Digital Twin Working Group's goal is "to create a vision that can clearly articulate the needs of owner-operators and asset owners related to digital-twin technologies and speak with a focused voice to the vendors providing digital twins solutions."

In a workshop at the 2022 ARC Industry Forum in Orlando, Florida this past June, subject matter experts from Dow, ExxonMobil, Shell and Chevron presented the working group's vision for more open and interoperable digital twin solutions that help ensure a smooth transition from design and build through operate and maintain and sustain value across an asset's entire lifecycle. In his opening remarks at this workshop, ARC Analyst Peter Reynolds commented, "The implications for this new initiative are far-reaching into the operating and business systems of energy and chemicals producers and their technology suppliers. Asset owners want to eliminate barriers to the interoperability and contextualization of disparate data sets while optimizing and automating business processes." (For more, see:www.arcweb.com/industry-best-practices/moving-toward-sustainable-asset-digital-twins). ❐

AspenTech

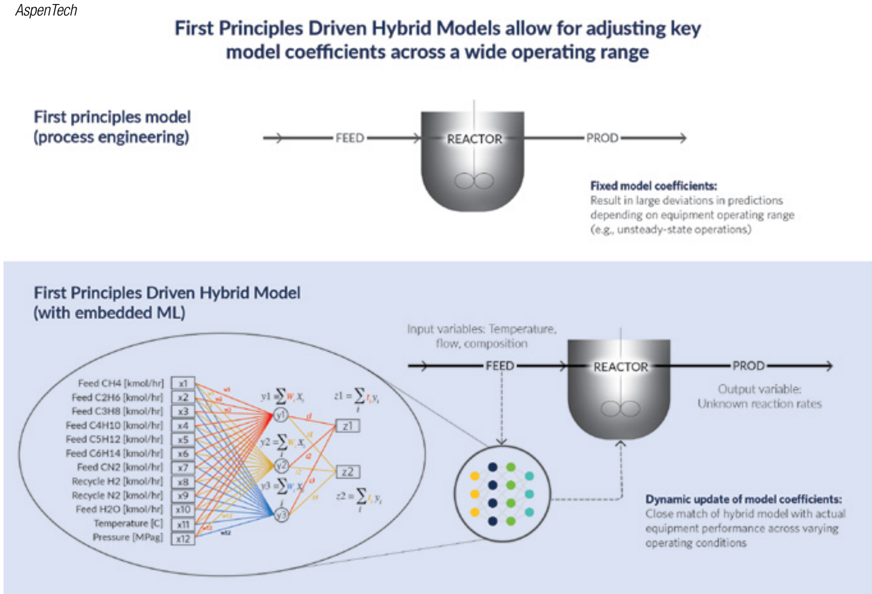


FIGURE 3. First principles-driven hybrid models allow key model coefficients to be adjusted across a wide operating range

real-time (or faster) response. In addition, it's important to build out connectivity to other software tools and data. "If an organization commits fully to simulation, the sky is the limit."

The potential benefits across the full spectrum of current advancements can return thousands to millions of dollars, according to Brown. "When trying to find a pareto optimum between maximizing profit and minimizing environmental impact, shortcuts are not acceptable. Our vision is that engineers should take the time to build a rigorous model with all the necessary detail and run a massively parallelized optimization to get the best available answer," he adds.

Opening up to external tools

Olivier Baudouin, process manager at ProSim (Labège, France, www.prosim.net), expands on the trend toward interoperability between modeling and simulation applications. "Originally, process simulation software were standalone, closed black boxes," he explains. "One of the major evolutions, which started in the middle of the 1990s, was the opening of the software to external tools on the one hand and being able to interoperate between them on the other hand."

According to Baudouin, emerging standards such as CAPE-OPEN play a major role here. He explains that thanks to these standards, a thermodynamic calculation server from one company can use a thermodynamic package from another supplier so the same thermodynamic package can be used throughout the life of a process — from its configuration based on available experimental data, to the control or optimization of a process, through its design or revamping phases. In a similar manner, component modularity and communications interfaces mean that the modules from any process simulation software can be used for unit operations.

Implementation challenges

Most of the implementation challenges mentioned for these types of advancements relate to the lack of clean, timely and accessible data; the shortage of plant personnel with the appropriate backgrounds in both industrial data science and process operations; and management buy in. And, of course, with more sensitive or proprietary data moving to the cloud to support digitalization and new attack vectors emerging daily, cybersecurity remains a challenge.

According to AspenTech's Khanlari, "A model based on process data will be no better than the data that went into developing or calibrating that model. There may be time periods requiring users to 'condition' data to be able to get the most out of it, for example, where the process is not steady, the process measurement is bad (for example, outside the measurable range of the instrument), the data does not close material balance, or the plant is operating in a regime that is out of the norm."

She also stressed that, just as for any other AI/ML application in the chemical industry, data processing should consider both sample bias and degrees of uncertainty. "An ML algorithm needs both success and failure data to be able to predict operations. However, failure data are typically rare. Similarly, the certainty of the predictions also plays a fundamental role in decision-making as it often requires large investments, time and resources."

Aveva's Gulati mentions that the most common implementation challenge for engineers is not being able to directly measure a specific process variable. "In the chemical industry, where plants are operating under extreme conditions, price point and practicality become barriers, so proxy technology, such as soft sensors, are great solutions that can feed the needed information into the digital twin technology."

As more and more plant data move to the cloud to help make them more widely accessible to the users that need it most, the cybersecurity challenge is to make those cloud-resident data secure from potentially malicious individuals, both external and internal to the enterprise. And while certainly not limited to either the chemical industries or modeling and simulation solutions, the critical balancing act between data access and data security remains a major challenge for digital transformation. "Very often, process data are treated as company intellectual property," Khanlari elaborates. "As a result, access can be on a need-to-know basis." She stresses the importance of documented processes, so the appropriate people can access the needed data while protecting the data from external unauthorized access/attacks.

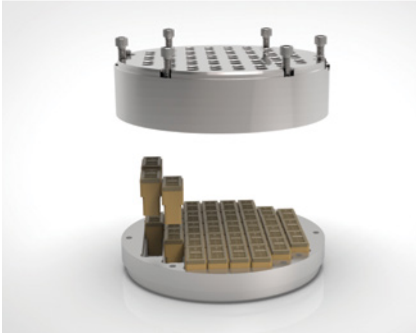
Chemstations' Brown adds, "Management buy-in is critical because this is a culture shift to have all process engineers trained and fluent in process simulation. Developing rigorous models requires skill, of course, but also time. We understand many organizations are running lean, so there has to be a vision to invest the required resources." ■

Paul Miller

Compressors, Fans, Blowers

Steel alloy compressor valve offers lower installed cost

Unlike its stainless-steel counterpart, designated StraightFlo SS (severe service), the new SE StraightFlo SE (standard edition) reciprocating compressor valve (photo) serves relatively non-corrosive compressor applications typically found in upstream and midstream gas-compressor markets. Gases encountered in these applications include sweet and sour natural gas, air, gas with natural gas liquids, and industrial gases such as oxygen, carbon dioxide, hydrogen, helium and acetylene. The company performed extensive development and testing of material options, settling on 4140 steel alloy for the StraightFlo SE valve. This introduction follows extended field trials in a full range of upstream and midstream applications. The SE valve has the same ability to extend run times up to 35 times and provide power savings or throughput increases up to 15%, says the company. — *Zahroof Valves, Inc., Houston*
www.zahroofvalves.com



Zahroof Valves

Blower package for pneumatic conveying systems

This company supplies a wide range of positive displacement (PD) continuous vacuum, pressure and vacuum/pressure system blower packages (photo) for conveying bulk materials. Packages are available for 2- to 10-in. conveying systems. Each blower package includes a silencer and is supported on a heavy-duty base, allowing easy access for cleaning. Built-in braces permit the entire package to be moved into position with a forklift during installation or maintenance. A heavy-duty drive guard totally encloses the drive to protect plant personnel. An expanded metal front allows the operator to visually inspect the belts without removing the guard and lets the heat from the belts dissipate for longer belt life. Routine maintenance is simplified by the drive guard's easy-access design. Every blower package incorporates an industry-proven positive displacement blower. The blower is dynamically balanced, and isolation pads are positioned between the blower and the base to reduce vibration and noise. An industry-proven motor that meets all NEMA specifications is standard on every package. Like the blower, the motor is mounted on isolation pads to reduce vibration. — *Coperion K-Tron Salina, Inc., Sewell, N.J.*
www.coperion.com

Coperion K-Tron Salina

This motor is thrice certified for use in hazardous locations

The IEC Zone 2 & 22 and UL Div 2, Class I & II, Triple-Certified motor (photo) is designed to comply with over 80% of global minimum energy performance standards (MEPS) and certificates, including North America and Europe. The IEC motor is UL and CE marked and complies with the U.S. IHP (integral horsepower) and E.U. EcoDesign requirements. The Triple-Certified motor is specifically designed to drive much of the auxiliary equipment in the oil-and-gas industry and is suitable for lubrication pumps, heat exchangers and blowers. These foot-mounted motors have a cast-iron frame and end plates, are inverter ready, and have Class F insulation with Class B temperature limits to ensure the motor performs reliably in oil-and-gas applications. A six-post terminal block in a large F3 (top mounted) terminal box provides easier, lower cost installation. Motors are IP66 to provide protection against harsh environments. — *ABB, Motion business, Ft. Smith, Ark.*
www.go.abb/motion

ABB, Motion Business

Electric two-stage, horizontal-tank air compressors

This company offers a line of electric two-stage, horizontal-tank stationary air compressors (photo) that are suitable for applications requiring greater pressure. The line displaces between 9.1 and 107.0 ft^3/min at 175 psi. The 22 belt-driven models in this two-stage horizontal-tank line provide an extensive range of size and power options. On the

Jenny Products

Vortab Co.

Kaeser Kompressoren

Aerzener Maschinenfabrik

Erdwich Zerkleinerungs-Systeme

smaller end, 2- and 3-hp models feature 60- and 80-gal tanks and displace between 9.1 and 13.4 ft^3/min. Larger units provide 5, 7.5 and 10 hp, displace between 18.3 and 43.6 ft^3/min and come with a standard magnetic starter. Tank sizes on the larger end range from 60 to 120 gal. All models at 10 hp or less come in one- or three-phase power. — *Jenny Products, Inc., Somerset, Pa.*
www.jennyproductsinc.com

Flow conditioners tame irregular fluid flows

This company's flow and process conditioners (photo) isolate flow disturbances and create a swirl-free, symmetrical and repeatable velocity flow profile in just a few pipe diameters to keep equipment running efficiently. The product line of inline and insertion-type flow conditioners nearly eliminates the upstream straight pipe run requirements for many types of equipment and instruments. They condition the flow stream into a regular flow regime to mimic adequate pipe straight run. The use of a flow conditioner also eliminates the pipe cost and technician labor for the purchase of additional lengths of pipe straight run and the labor for its installation. The flow conditioners can be made from carbon steel, 316L stainless steel or Hastelloy C-276. — *Vortab Co., San Marcos, Calif.*
www.vortab.com

These two new blowers are energy efficient

With a flowrate of 18 to 72 m^3/min and pressure differentials from 0.3 to 1.1 bars, as well as a selection of motors ranging from 45 to 110 kW, the FBS rotary-screw blower continues the success story of its smaller sibling, the EBS, while setting new standards in terms of energy efficiency, space-saving design and automation. The SFC version (photo) is equipped with a frequency converter and a synchronous reluctance motor — a slip-free design that combines all the advantages of high-efficiency permanent-magnet motors with those of robust, service-friendly asynchronous motors. Thanks to variable speed control, the flowrate can be adjusted as required and a control range of 1:4 is achieved, allowing exceptionally dynamic operation. The STC version is now equipped with an energy-saving IE4 Super Premium Efficiency motor, which reduces energy consumption. — *Kaeser Kompressoren SE, Coburg, Germany*
www.kaeser.com

A new blower generation with increased efficiency

New blower generations of the Delta Hybrid and Turbo series (photo) offer more efficiency in the aeration tank of wastewater treatment plants (WWTPs). Depending on the region, time of day and season, as well as the amount of precipitation and pollution load, municipal or industrial biological WWTPs experience different degrees of pollution and strong fluctuations within the load profiles. Due to this fluctuating load profile, the air demand in the aeration tank changes continuously. With its Performance^3 efficiency concept, this company offers a unique strategy for the exact control of the load changes and thus an optimal solution for an energy-efficient oxygen supply. Thanks to the ability to combine of different technologies, sizes and design points, this company's blowers can allow energy savings of up to 30%. — *Aerzener Maschinenfabrik GmbH, Aerzen, Germany*
www.aerzen.com

One-step disposal of harmful refrigerants and compressor oils

The fully automatic KAA100 extracts both refrigerant and compressor oil from intact, as well as defective, refrigeration devices and air-conditioning systems in a single work step. The plant complies with the ATEX Directive 2014/34/EU, is tested in accordance with the Ordinance on Plants for Handling Substances Hazardous to Water (AwSV) and is compliant with German Technical Instructions on Air Quality Control (TA Luft). On request, the engineering company also plans and implements complete refrigeration device recycling plants, including separating and shredding machines, as well as exhaust-air purification technology in a closed system. — *Erdwich Zerkleinerungs-Systeme GmbH, Igling, Germany*
www.erdwich.com ■

Gerald Ondrey

New Products

Transport hazardous goods with this new IBC

The new Ecobulk SX-D intermediate bulk container (IBC; photo) is designed for transporting hazardous goods, such as flammable or highly combustible liquids. The IBC has already received the quality seal of the FM Global Group. It has a closed, fire-resistant hull in addition to the classic steel grid. This hull is welded to the integrated bottom plate, forming a separate sealed containment basin around the inner bottle of the container. The double-wall construction provides effective additional protection against leakage and stops sensitive liquids from escaping, even in extreme situations, such as in the event of a fire with very high temperatures. — *Schütz GmbH & Co. KGaA, Selters, Germany*
www.schuetz.net

Ethernet remote I/O modules with conditional logic computing

BusWorks NT series remote I/O modules (photo) are now enhanced with conditional logic. The conditional logic increases the functionality with a system of rules that allows extremely complicated decisions based on relatively simple "yes/no" questions. For example, reading an analog or digital input value can trigger an action to happen as a result. This value could be used to control a relay when one or more conditions occur. Another example would be when a discrete input is "On" and a temperature threshold is crossed. More complex math computation and logic are also an option. The modules support up to 64 conditions using "if/then/else" statements. — *Acromag, Wixom, Mich.*
www.acromag.com

This natural-gas analyzer now has new features

A new version of the J22 tunable diode-laser absorption spectroscopy (TDLAS) gas analyzer (photo) now includes support for the Modbus TCP/IP protocol, which enables users to communicate with their analyzers from a central network location in a bidirectional, secure point-to-point manner. Combined with the addition of a native web server, this enables users to easily monitor, configure and service analyzers remotely. The web server also can be used to optimize the analyzer. — *Endress+Hauser, Greenwood, Ind.*
www.us.endress.com

Silicone-coated gloves for window manufacturing

The RepTek Grip silicone palm-coated gloves provide adhesion resistance paired with high cut resistance and dexterity. Hot butyl can become bothersome when it sticks to gloves, shortening the life and costing more money. This new silicone coating prevents sealant or hot-melt buildup and stands up to everyday wear and tear, lasting up to six times longer than most standard gloves. The GPD487 (photo) features a Hyperon ANSI cut-level A5 shell, and the GPD787 uses the company's AeroDex Technology to achieve cut level A7 protection. Both options are cool and lightweight, providing long-wearing cut-resistance, so workers do not have to sacrifice dexterity or comfort to stay safe. — *Magid Glove & Safety Manufacturing Company, LLC, Romeoville, Ill.*
www.magidglove.com

A biosolids granulator for the treatment of sewage

The biosolids granulator (photo) is a dry-on-demand system for the treatment of sewage sludge from municipal and industrial wastewater-treatment plants. It combines existing centrifuge-based dewatering with proven drying technology. This process, said to be unique in the world in this form, uses the dewatered solids ejected directly from the rotating centrifuge bowl. This is then immediately heat-treated and solidified by the primary direct-heat input stream. The solid particles are then further dried by the secondary hot airstream in the main drying chamber. The result is an improved dried granule with up to 50% dry solids and a consistent pathogen count below 100,000 cfu/g. These process results can be achieved using either low-temperature (75–90°C) waste heat available on site, heat generated from a fuel source or a combination of both. — *GEA Group, Düsseldorf, Germany*
www.gea.com

Schütz

Acromag

Endress+Hauser

Magid Glove & Safety Manufacturing Company

GEA Group

Draeger

Valmet

Metso Outotec

Amandus Kahl

IDEC

Optimized safety and efficiency in confined-space operations

The new X-Viz confined space monitoring system (photo) is a complete safety-monitoring system designed to meet OSHA requirements during plant turnarounds. By integrating gas detection, video monitoring, alarms and access control technologies, X-Viz allows fewer safety attendants to remotely monitor a greater number of confined spaces. It also reduces overall labor costs and delegates safety supervision to skilled specialists. The high-quality, real-time video footage allows safety professionals to exponentially increase the level of safety at a reduced cost. — *Draeger, Inc., Telford, Pa.*
www.draeger.com

This butterfly valve has new features

The Neles Q-Disc butterfly valve (photo) has a new high-performance feature to help with flow balancing in control valve applications. Q-Disc is specifically designed for control applications. One of its key benefits is that it helps to avoid oversized actuators for control-valve packages, which saves energy and costs. Designed for challenging flow conditions, Q-Disc can be utilized to avoid cavitation in low opening angles, and it also provides market-leading noise reduction capabilities — even up to 12 dB in certain flow conditions, the company says. Q-Disc also helps in optimizing the entire valve-actuator package by making it possible to reduce the impact of dynamic torque caused by the flow. Q-Disc is available as a modular option for a wide range of butterfly valves, and it can be used for a temperature range up to 600°C. — *Valmet Oy, Espoo, Finland*
www.valmet.com

A compact pelletizing plant for iron-ore processing

This company has optimized its existing induration technology, offering and launched its Compact-sized Pellet Plant (photo). The plant design is based on a 3-m wide indurating machine, building on the state-of-the-art design of the company's larger (4-m wide) product range. The new compact plant offers the same plant performance and product quality as the larger-size plants. Three standard sizes (capacities) are offered: 189 m^2 (1.2–1.5 million metric tons per year (m.t./yr)); 288 m^2 (1.7–2.3 million m.t./yr); and 315 m^2 (2.0–2.6 million m.t./yr). — *Metso Outotec Corp., Helsinki, Finland*
www.mogroup.com

A new type of pellet mill for producing green forage

Specially developed for green forage pelleting, the 55-1500 pellet mill (photo) is designed to produce smaller and thinner pellets, as well as coarser grass cobs. The pan grinder rollers, measuring 450 to 550 mm, with a speed of only 2.5 m/s, enable very good defibration of the product. Due to the larger die diameter of 1,500 mm and a larger, open perforated surface, the 55-1500 easily processes higher volumes than the company's 45-1500 pellet mill, while achieving an increase in output of up to 50%. It also requires only one motor instead of two as before. This makes the machine particularly energy-efficient, while offering low maintenance. Its footprint is identical to that of the 45-1250 pellet mill, so it can be easily integrated into existing drying plants. — *Amandus Kahl GmbH & Co. KG, Reinbek, Germany*
www.akahl.com

Tools for improving wire connections to terminals.

Properly installed ferrules provide dependable wire terminations to both screw and push-in terminals, but installers and technicians need suitably rated parts and associated tools for making these connections. This company has therefore introduced a complete product line of S3TL series ferrules, wire strippers, crimpers (photo) and screwdrivers. The S3TL ferrule product line includes various sizes accommodating wire gauges from AWG 26 to AWG 8, each with one or two wires, depending on part number. Each ferrule incorporates an electrically insulated cover, which is color-coded using the German Weidmüller standard, for easy recognition by installers. The ferrules are UL 486F certified when used together with S3TL series crimping tools. — *IDEC Corp., Sunnyvale, Calif.*
www.idec.com/usa

This conveying system is stable and reliable

Schenck Process

The E-finity (photo) is a patented, continuous dense-phase conveyor system for fragile materials. Precise pressure monitoring and airflow corrections allow the system to operate efficiently under all conditions, while gently inducing materials through the convey line in slug form. E-finity is suitable for granular and pelleted materials, and has proven itself on many projects for pet foods, cereals, nuts, grains and prills. Unique E-finity air controls can employ a single air source to operate two to three different systems simultaneously. — *Schenck Process LLC, Kansas City, Mo.*
www.schenckprocess.com

Reusable shipping container for hazardous materials

Labelmaster

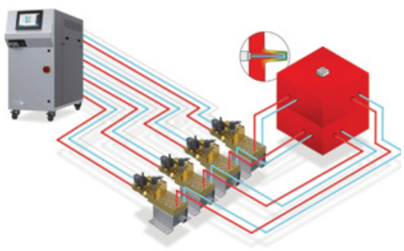
Capsuloc (photo) is a new reusable shipping container for transporting flammable liquids. Made of hard plastic and featuring a twist-on lid, Capsuloc is a lighter, safer and more convenient alternative to traditional metal "paint can" secondary-containment packaging used for hazardous materials. Capsuloc's advanced design provides a compliant seal without needing lock rings, and opens and closes by simply twisting the cap with no tools required. These durable containers can be reused repeatedly without denting or having to replace lock rings, and are completely recyclable. Having passed rigorous UN testing, Capsuloc can be compliantly shipped with an outer UN fiberboard box by all modes of transportation. Capsuloc container kits weigh 32% less than paint can kits, so they cost less per unit to ship. Futhermore, Capsuloc kits are half the size of traditional paint cans, meaning twice as many kits fit on a pallet, so shippers can keep more inventory in the same space. Finally. Capsuloc's advanced sealing technology makes it easier to open, close and ship, while reducing spills, leaks and the risk that comes with using sharp tools to open and close containers. Capsuloc kits are available with different-sized pressurized glass bottles, pouches and outer boxes. — *Labelmaster, Chicago, Ill.*
www.labelmaster.com

Contact angle technology for wetting measurements in QC

Krüss

With Ayríis (photo), this company has optimized the contact-angle method for quality assurance and developed the first solution for measuring the 3D contact angle. The instrument creates a virtual 3D model of the water drop dosed during the measurement and determines the contact angle reliably and automatically on the basis of this spatial image. The measurement takes

Spectro Analytical Instruments



Regloplas

Shimadzu Scientific Instruments

MSA Safety

only seconds and requires no prior knowledge or training. To prepare the quality-control (QC) checks, sample types can be created via the touch display and tolerance limits for the contact angle can be set. — *Krüss GmbH, Hamburg, Germany*
www.kruss-scientific.com

An analyzer for materials-control analysis

The SpectroMAXx LMX10 arc/spark optical emission spectrometry (OES) analyzer (photo) performs fast, accurate, advanced elemental analysis in metal-producing and fabricating plants, as well as iron and non-ferrous foundries. The LMX10 OES is said to deliver outstanding repeatability, reproducibility and reliability in material control analyses from incoming materials to in-process testing to final quality inspections — adding certainty to critical supply chains. Advanced diagnostics and easy maintenance prevent expensive downtime. In addition, the analyzer features the company's proprietary iCAL 2.0 calibration logic, which requires only 5 min, and a single sample per day, and automatically compensates for most changes in environmental temperature or pressure. Conventional analyzers may need 30 or more minutes for standardization, plus reruns whenever site conditions change. — *Spectro Analytical Instruments GmbH, Kleve, Germany*
www.spectro.com

Efficient cooling of die-cast components with hotspots

Demanding die-cast components, such as structural components in the automotive sector (megacastings), place special requirements on the temperature control, in particular on the cooling of so-called hotspots. The jetPulse system (photo) offers a reliable and economical solution for cooling such hotspots in a die-casting die. The jetPulse system offers two unit sizes (30 or 100 L). Up to six multiJet distributors with eight channels each can be connected per unit. These reliably cool up to 64 individual hotspots with pinpoint accuracy and cycle control. The system is supplemented by the flowrate monitoring of each individual channel with the company's flowControl unit. The system detects problems in individual cooling channels at an early stage and thus avoids costs due to quality problems and rejects at an early stage. — *Regloplas AG, St. Gallen, Switzerland*
www.regloplas.com

Achieve fast, high-resolution detection with this spectrometer

The EDX-7200 energy-dispersive X-ray fluorescence spectrometer (photo) is equipped with a high-resolution silicon drift detector (SDD) to achieve a higher count rate and detection efficiency than its predecessor models. Along with the SDD, the EDX-7200 incorporates a high-speed circuit that achieves highly precise analysis of the target element in a shorter measurement time. It increases the count rate by up to 30 times compared to the former model (EDX-720). Improved algorithms and performance also help to reduce measurement times. In addition, the EDX-7200 delivers high-sensitivity performance, improving the lower detection limit of trace elements in metal by up to six times that of the previous model. With the SDD, the EDX-7200 offers superior energy resolution compared to earlier models. This reduces the effects of overlapping peaks of different elements, enhancing the reliability of the analysis results. This flexible instrument accommodates all types of samples — from small to large, from solids to powders to liquids. Options include a vacuum measurement unit, helium purge unit (for highly sensitive measurement of light elements), and a 12-sample turret for automated continuous measurements. The new automatic measurement time-reduction function automatically switches to the next analysis channel if a controlled substance clearly has a high or low concentration, making evaluation possible while measurement is underway. This achieves more efficient screening analysis. — *Shimadzu Scientific Instruments, Columbia, Md.*
www.ssi.shimadzu.com

A next-generation system to reduce fire and gas hazards

The new HazardWatch FX-12 fire and gas system (photo) is designed to help process and plant engineers reduce hazard vulnerability while meeting

demanding safety standards in hazardous industries, including oil-and-gas production, tanker loading and unloading, petrochemical refining and storage, pipelines and gas compressor stations, hydrogen production, electric power generation, automotive and pharmaceutical manufacturing. The HazardWatch FX-12 System is designed with an Allen-Bradley ControlLogix programmable logic controller (PLC) technology and advanced gas- and flame-detection field devices. Allen-Bradley DLR-enabled communication protocols allow secure integration with other products. A complete solution in a single system, the HazardWatch FX-12 System includes: a standalone local fire and gas alarm panel with touchscreen operator interface; a redundant power supply to support the fire and gas system according to NFPA 72; easy integration with third-party auxiliary devices, such as horns, beacons and fire suppression systems; and FM-approved EtherNet/IP system communications. The HazardWatch FX-12 can accommodate up to 12 field devices per alarm panel, with the capability to network up to 12 panels. — *MSA Safety, Inc., Cranberry Township, Pa.*
www.msasafety.com

A smaller AODD model is added to this pump product range

The extensive range of Finnish Thompson FTI air-operated double diaphragm (AODD) pumps has recently been expanded with the addition of a new 0.25-in. non-metallic model, the FT025 (photo), available in polypropylene, polyvinylidene fluoride (PVDF) and conductive polypropylene for use in ATEX areas. The FT025 model delivers a maximum flowrate of 22 L/min (5.8 gal/min) at a maximum air-supply pressure of 120 psi (8.3 bars). The FT025 extends the minimum flow capabilities of AODD pump for a wider range of pumping applications. Furthermore, FT025 pumps are suited to handling abrasive, viscous and shear-sensitive liquids and even “dirty” liquids, with particles up to 1.8 mm (0.06 in.) in diameter. Typical applications will include handling acids, bases, plating solutions, wastewater, paints, inks, solvents, ceramic slip and glaze, lubricants and oils. The FT025 includes a unique lube-free air valve design, which means that significantly fewer components are used compared to other air valves, resulting in reduced servicing time and the associated maintenance costs and downtime. The air valve components include a low-friction slide valve on a ceramic plate to allow for long lifetime and superior sealing, and a molded Buna rubber gasket that ensures total sealing and eliminates flat gasket tearing. — *Michael Smith Engineers Ltd., Woking, U.K.*
www.michael-smith-engineers.co.uk


Michael Smith Engineers

AttaBox

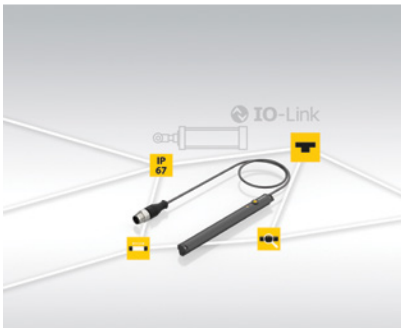
These enclosures now feature more secure gaskets

Instead of traditional neoprene rope gasketing, new Foam-in-Place gaskets have been added to all product sizes in the Heartland series of polycarbonate and non-metallic electrical and industrial enclosures (photo). These gaskets provide full secure contact to the mating cover surface with a continuous overlapping seal that ensures no air gaps, no glue joints and no shrinking of gasket size due to stretching of the material. The result is maximum sealing integrity and reliable protection of all wiring, connections, instrumentation and controls housed by Heartland enclosures. Heartland enclosures can be configured with either a screw cover or a hinged cover, and are available in 13 sizes with either opaque or clear smoked covers. — *AttaBox, a brand of Robroy Enclosures, Belding, Mich.*
www.attabox.com

Fluid Components International (FCI)

A compact flowmeter designed for tight equipment areas

The FS10i flowmeter series (photo) is designed to measure the flowrate of natural gas. The FS10i meter is accurate to ±1.5% of reading, ±0.5% of full scale, with repeatability of ±0.5% of reading and has a response time of 4 s. Designed with highly stable direct mass-flow sensors, FS10i flowmeters require no additional pressure or temperature sensors or other components to infer flow measurement. The sensor does not foul or clog, and requires no routine maintenance, ensuring continuous operation. FS10i flowmeters provide a fluid-matched, calibrated and linearized 4–20-mA output of flowrate, and a user-programmable high- or low-flow alarm or trip point. For visual indication, the flowmeters include a 10-segment LED array display that illuminates proportionally to the flowrate and flashes if an alarm trip occurs. Available in both inline and insertion-style configurations, FS10i meters support installation in line sizes from 1 to 20 in. (DN25 to DN500). They operate over a wide turndown ratio from 1 to 400 std. ft^3/min, depending on fluid media and line size. Their 316L stainless-steel construction ensures corrosion resistance. — *Fluid Components International LLC (FCI), San Marcos, Calif.*
www.fluidcomponents.com



Hans Turck GmbH & Co.

Magnetic position sensors with IO-Link

This company has extended its offering of compact position sensors with the WIM-IOL series (photo) for detecting magnetic pistons in pneumatic or hydraulic cylinders. The new series consists of eight sensors with IO-Link 1.1, covering measuring ranges from 32 to 256 mm. IO-Link and the integrated pushbutton enable users to teach the measuring range of sensors quickly and conveniently to the stroke of the pistons in the cylinder. This simplifies mounting compared to analog sensors, as these have to be fitted either exactly to the dead points or operate with correction factors in the controller. The IP67 sensors operate with a 15-bit resolution. Typical applications include feed detection in injection molding machines or automatic screwing machines, the positioning of the welding head with ultrasonic welding or the monitoring the foil tension in packaging machines. — *Hans Turck GmbH & Co. KG, Mülheim an der Ruhr, Germany*
www.turck.com

Gericke USA

One controller manages multiple feeders

The GUC-F Universal Feeder Controller (photo) allows additional feeding capacity to be installed to meet increased or changing production demands without purchasing additional, individual controllers for each feeder. Devised to future-proof against sudden demand spikes and provide flexibility to accommodate frequent recipe changes, the controller instrumentation automates control over weighing, dosing and feeding from up to four feeders on up to four different processing lines from a single HMI screen. Accurate weighing and precise powder feeding are assured in a streamlined production operating with reduced equipment, labor and maintenance costs. Developed for food, chemical, pharmaceutical and other powder and bulk-material feeding processes, the GUC-F is delivered preconfigured based on the type of feeder or feeders, required modes of operation, and use of frequency converters for easy installation and fast setup. — *Gericke USA, Somerset, N.J.*
www.gerickegroup.com ■

Mary Page Bailey and Gerald Ondrey

Heat-Transfer Fluid System Venting

Department Editor: Scott Jenkins

Heat transfer fluids (HTFs) provide heating and cooling of process equipment, including reactors, autoclaves, distillation columns, reboilers, mixers and dryers. HTF system designs should provide for effective system venting, both of residual water at startup and of degradation products during operation.

Water concerns

When commissioning new HTF systems (Figure 1), a primary concern should be the effects of water: new systems can be vulnerable to excessive pressures from residual water. Hydrostatic pressure tests (leak checks) conducted on the system during manufacture or onsite after maintenance can be a typical water source. Complete water removal can be hindered by traps and piping elevation changes. The best system designs provide piping installations with slopes toward strategically placed low-point drains. After water is drained, but prior to filling, the system may be further dried by purging warm, dry air (or N_2) through the system's circuits until the exiting gas dewpoint reaches –34 to –40°C, indicating moisture has been adequately dried. Close attention to the drying process will significantly reduce the time needed to reach the intended high operating temperatures at start-up.

Removing moisture at start-up

Prior to circulation, ensure the cold liquid level of the HTF in the system is adequate. This is typically indicated by the expansion-tank liquid level instrument (Figure 1). Next, heat the liquid slowly while circulating throughout all piping circuits with the assumption that water content may be excessive. Valve A is closed, and valves B and C are open. The HTF is circulated through the expansion tank and heats to just above 100°C. This temperature forces the moisture to flash into the vapor space of the expansion tank. Valve E is open, and the ingress of inert gas sweeps the water vapors from the vapor space downstream to a catch tank or flare system. The process continues until moisture symptoms — including pump cavitation, erratic flowrate at the discharge side of the pump, and rattling, knocking and boiling sounds in the expansion tank and pipe — subside.

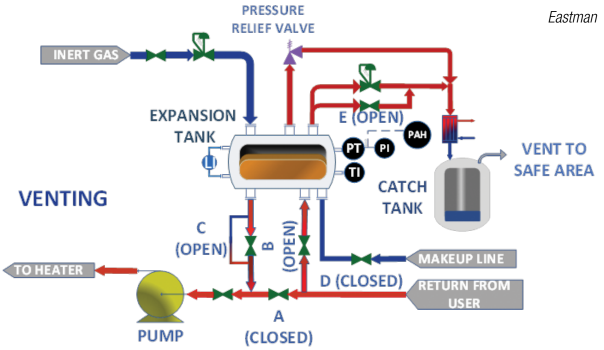


FIGURE 1. Heat-transfer fluid systems need to be vented for residual water at start-up and for fluid degradation products during operation

Once the HTF is deemed adequately dried, the fluid should be capable of continued heating to higher operating temperatures. Typical valve alignment during normal operation is for valves A and B to be open, and valves C and E to be closed. This valve placement allows a lower temperature in the expansion tank (commonly about 25% of system volume), where its thermal degradation rate is negligible.

Venting degradation products

In operation, the HTF deteriorates at increasing rates as the operating temperatures approach the bulk operating maximum for the specific HTF, altering the condition and composition of the HTF. Thermal degradation leads to the formation of both high-boiling compounds, which increase fluid viscosity and potential solids formation that increase risks of coke or fouling deposits, and low-boiling compounds that decrease the fluid's viscosity and that have boiling points lower than the boiling range of the HTF. Additionally, increasing low-boiling content can lead to flashpoint depression by 45°C or more.

The low boilers can be managed by routine system venting. Systems are best vented only when the concentration of low boilers exceeds recommended limits based on sample analysis of the fluid.

The same procedure is followed when commissioning a new system, except higher temperatures are needed. For many organic HTFs, the venting procedure is conducted at fluid temperatures near 180 to 200°C. This temperature range supports flashing into the vapor phase and separation of the low boilers from the heat transfer fluid for removal without incurring a significant loss of the HTF components. With valve A closed and valves B and C open, all the fluid flows through the expansion tank. This process raises the fluid temperature in the expansion tank and increases the partial pressures of the low-boiling degradation products. This allows the low boilers to flash into the vapor phase, where their removal is supported by opening valve E. Inert gas can be used to efficiently sweep those vapors across the surface of the liquid and out of the vent line, where they can be condensed and collected for disposal.

Circulation through the expansion tank also ensures that all HTF benefits from reducing levels of low-boilers.

After the venting process, return to the typical valve alignment for normal operation, where valves A and B are open, and valves C and E are closed. This arrangement provides for the thermal expansion and contraction of the HTF volume to and from the expansion tank with temperature changes. Continual venting and purging is not recommended, as this can deplete fractions of the HTF itself, creating related changes in its properties, performance and life expectancy. ■

Editor's note: This content was drafted by Kapil Bathla, a product development and customer technical support specialist at Eastman Chemical Co. (Kingsport, Tenn.; www.eastman.com).

Concepts surrounding the hydrogen economy are quickly becoming practically realized as industries turn their focus to decarbonization initiatives. To address this rapidly evolving sector, the HydrogeNext conference (www.hydrogenextevent.com), taking place October 3–5 at the Gaylord Rockies Resort & Conference Center (photo, p. 28) in Denver, Colo., is bringing together technical and business experts to share their knowledge about the full hydrogen value chain, including production technologies, handling, storage and safety considerations, as well as updates on carbon capture and significant use cases. Safety is of particular importance for the advancement of hydrogen-based decarbonization strategies.

According to the Compressed Gas Association (www.cganet.com), only 12% of Americans believe that hydrogen is a "very safe" energy source, and 92% of Americans say it is important to ensure safety standards are set before we begin expanding and scaling up hydrogen technologies. At HydrogeNext, CGA president and CEO, Rich Gottwald, will give a presentation about the Safety is Step One initiative, which is focused on emphasizing existing hydrogen standards and developing new standards for emerging hydrogen-related applications. "We cannot make the revolution a reality without assuring that hydrogen technology is handled safely and that this is communicated to the consumer," says Gottwald. Other highlights of the HydrogeNext program include the presentation of successful hydrogen-economy use cases from industry leaders like Worley, Southern Company, GE Power, Kiewit and more. The following Show Preview includes the HydrogeNext agenda and describes two of the HydrogeNext exhibitors and their technology offerings for the hydrogen economy.

Vacuum pump systems for hydrogen handling

Liquid hydrogen storage and transport requires vacuum-insulated vessels to minimize heat transfer. This application requires pumping air from the vacuum insulation space to the milliTorr pressure range. The Varodry and Ruvac WSU vacuum pumping systems (photo) are appropriate for such hydrogen-handling applications because they do not require cooling water. There is also a number of ranges with ATEX and EXP motor options available, including: Trivac, Dryvac, Ruvac, Leyvac, Screwline, Turbopump, Ecodry and Scrollvac. Booth 118 — *Leybold USA Inc., Export, Pa.*
www.leyboldproducts.us

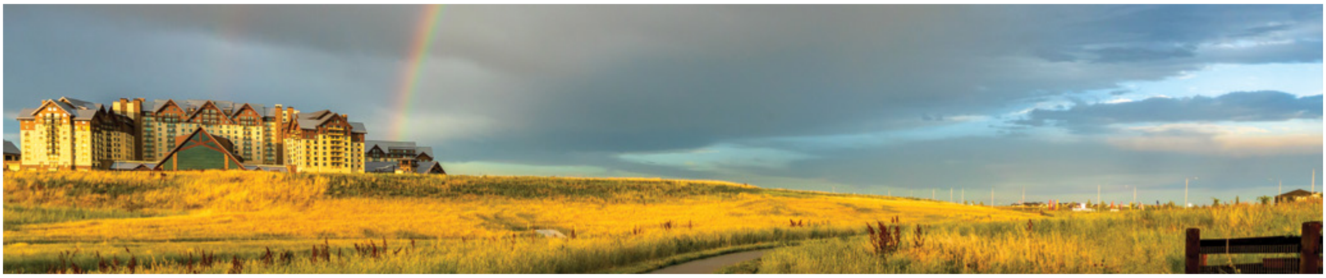
Demonstration project for fuel-cell-powered datacenter

This company — in collaboration with Microsoft and Ballard Power Systems — has launched a three-year project to demonstrate a power system incorporating a large-format hydrogen fuel cell to produce reliable and sustainable backup power for datacenters. The project is supported and partially funded by the U.S. Department of Energy (DOE) under the H2@Scale initiative and backed by the National Renewable Energy Laboratory (NREL). The partners are demonstrating a 1.5-MW backup power-delivery and control system that would meet or exceed the performance of current diesel-engine systems. As the prime contractor on the project, Caterpillar is providing the overall system integration, power electronics and controls that form the central structure of the power solution, which will be fueled by low-carbon-intensity hydrogen. Microsoft is hosting the demonstration project at a company datacenter in Quincy, Wash. (photo, bottom), while Ballard is supplying an advanced hydrogen fue-cell module (photo, top). The NREL is performing analyses on safety, economics and greenhouse-gas impacts. The demonstration will provide key insights into the capability of fuel-cell systems to serve multi-megawatt datacenters by providing uninterruptible power that supports 99.999% uptime requirements. The project will also explore the scalability of fuel-cell systems powered by low carbon-intensity-hydrogen from cost and performance perspectives, including 48-h operation using onsite fuel, power transfer time and load acceptance. Booth 201 — *Caterpillar Inc., Deerfield, Ill.*
www.cat.com

HYDROGENEXT
Advancing hydrogen's role in decarbonization

Leybold USA

Caterpillar



HydrogeNext Agenda

Monday, October 3
7:00 am–6:30 pm:
Registration Hours

5:30 pm - 6:30 pm:
Happy Hour

Tuesday, October 4
8:00 am–9:30 am:
The Way Forward — Opening Keynote Presentations

10:00 am–11:30 am:
Safe at any Speed? Debating the Pace of the Energy Transition

1:00 pm–2:30 pm:
Usage, Demand and Market for Hydrogen

3:30 pm–5:00 pm:
H_2 Technology Updates: Current Production and Emerging Methods

Wednesday, October 5
8:30 am–9:00 am:
Bitcoin's Vital Role in the Energy Transition

9:00 am–10:00 am:
Hydrogen Storage Considerations

10:30 am–12:00 pm:
Safety Issues and Policies Around Hydrogen

1:00 pm–1:20 pm:
Hydrogen Case Studies in Decarbonization

1:20 pm–1:50 pm:
Hydrogen Firing at Long Ridge Energy Center: What it Tells Us about the Future of Hydrogen in Combustion Turbines

1:50 pm–2:15 pm:
Hydrogen Case Studies — Southern Co. and GM Super Trucks

2:15 pm–3:00 pm:
World's Largest Hydrogen Fuel Blending at Plant McDonough-Atkinson

3:30 pm–5:00 pm:
Carbon Capture Technology Development and Integration Considerations

Mary Page Bailey

For details visit adlinks.chemengonline.com/82585-11

POWTECH 2022

Powtech 2022, a leading tradefair for powder and bulk solids processing and analytics, takes place from September 27–29 in Nuremberg, Germany. Visitors will experience the latest mechanical equipment and systems for the processing, analysis and handling of powder, granulate and bulk solids in four halls, including the state-of-the-art Hall 3A. This year's tradeshow, which is running together with Fachpack, expects over 1,600 exhibitors from Europe.

In lectures, seminars, live demonstrations, guided tours and special shows, visitors will receive useful practical knowledge from speakers. In the Expert Forum "stagetalks," the focus will be on innovative processes for modern battery and energy-storage production. In the food sector, one topic will be protein shifting in the drying of vegetable protein sources.

What follows is a sample of some products being exhibited at the show.

Mixing solutions to save energy, time and space

The High Efficiency Shovel (HES; photo) is a special shovel for mixing solids in horizontal Ploughshare mixers. The tool is designed to require less drive power than a standard shovel. Unlike standard shovels, this in-house development has an opening in the shovel blade. This corresponds to 85% of the surface area. Depending on the product, the HES permits a reduction of the startup torque by up to 20% and reduces the reactive power. This makes it possible to design a mixer with a lower motor rating. When used with the Ploughshare mixer, the design reduces torque by approximately 10% to save even more energy. The HES is suitable for industries that process dry, free-flowing solids with small particle sizes. Hall 3, Stand 249 — *Gebr. Lödige Maschinenbau GmbH, Paderborn, Germany*
www.loedige.de

Mixing and dispersing equipment for new trends

This company will present, among other products, a Big-Bag Tower with the optimized discharge aid Flex FSA for emptying poor-flowing powders without residue, as well as the inline powder wetting and dispersing machine Conti-TDS 3. The Multipurpose X100 disperser can be used for different tasks, such as jet-stream mixing and dispersing, as well as mixing and dispersing processes, and for the inducting and wetting of powders, through simple replacement of the tool shaft. Dispersers of the Multipurpose series are used in chemical, food, cosmetics and pharmaceutical production. Also showcased is the new BATT-TDS powder dispersing system (photo), which reduces manufacturing times for lithium-ion-electrode slurries in battery production from currently between two and six hours to just a few minutes. Hall 3, Stand 329 — *ystral gmbh, Ballrechten-Dottingen Germany*
www.ystral.com

A sinter-plate filter for higher temperatures

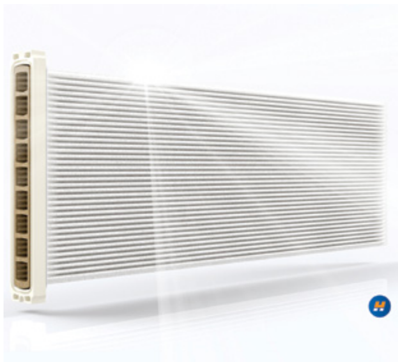
This company's Sinter-Plate Filters with PE-based matrix base materials can be used at operating temperatures of up to 70°C and, as a thermostabilized variant, up to 100°C. With the newly developed, patented BETA (photo), based on a sintered matrix made of PPS, now allows the use of all known features of the classic sinter-plate filter up to a continuous operating temperature of 160°C. The new filter medium is extremely resistant to chemical attack and also hydrolysis, as well as having a pH-resistance range of 1 to 10. In addition, the new filter medium can be operated with reduced pre-cleaning pressure, leading to lower operating costs and significantly increased energy efficiency. Pilot tests have been performed on a variety of applications, including dryer applications, biomass-incineration plants, extraction from rotary kilns, glass tank dedusting and high-temperature filtration behind mill systems. Hall 3, Stand 349. — *Herding GmbH Filtertechnik, Amberg, Germany*
www.herding.com

Improving product yields using jet nozzles

Depending on the material that is dried in a Solidmix vacuum-contact dryer, the price per gram of the final

Gebr. Lödige Maschinenbau

ystral



Herding

Ekato Systems

Fritsch

UWT GmbH Level Control

Freeman Technology

dried product varies immensely. For example, many users that are working in the active pharmaceutical ingredient (API) drying business have high expectations on the achievable yields in their process equipment. To address this topic, this company was looking for devices that can improve the final yield significantly while still meeting any FDA- and ATEX-related requirements. The YieldBlade (photo) mainly consists of one or more flat jet nozzles that are installed to the inner side of the Solidmix lid that clean off the remaining material with pressure surges. Depending on the requirements, the system can be designed as working completely manually by activating the gas jets with a manual valve. It can also be implemented into the automation system, resulting in a fully automatic opening and closing of the valves. Hall 3, Stand 549 — *Ekato Systems, GmbH, Schopfheim, Germany*
www.ekato.com

Introducing two new particle-size analyzers

The Analysette 22 NeXT Nano (photo) is a laser-based particle size analyzer that is said to offer the highest accuracy and sensitivity — even with the smallest particles. The system has a wide measuring range of 0.01 to 3,800 µm. The company also offers an economic alternative, the Micro version, which has a smaller measuring range from 0.5 to 1,500 µm. Both systems are designed with just one laser and a number of patented features for maximum durability with minimum maintenance. Another product launch at the show is the Mini Cutting Mill Pulverisette 29, an inexpensive cutting mill for small sample quantities, making it suitable for sample preparation of grains, other seeds or plastics. The unit has a variable rotational speed from 500 to 6,000 rpm, a maximum particle feed size of 13 mm and sieve inserts from 1 to 6 mm. It is easy to clean, and the grinding chamber is made of 316L stainless steel. Hall 4A, Stand 517 — *Fritsch GmbH, Idar-Oberstein, Germany*
www.fritsch.de

New solutions for radar level measurement

This company has extended its non-contact radar series NivoRadar for continuous level measurement. The NivoRadar NR 4 (photo, right) is equipped with 80-GHz FMCW technology and a very narrow beam angle. This high-frequency signal is emitted in a sawtooth wave format, reflected by the medium and received again by the sensor. The frequency difference, which is directly proportional to the distance, is then further processed and the output produced as a level signal. Thanks to the high degree of protection, the NivoRadar NR 4 is particularly suitable for bulk goods applications. Installation is possible in storage, process and intermediate bulk container (IBC) tanks, as well as freestanding heaps of material. It measures the lightest and heaviest bulk materials in all industries, such as powder, building materials, chemicals, wood or food. Reliable measurement results are achieved even with a steep angled cone. Optimized sensor material and a robust design ensure durability even under harsh environmental conditions. As a counterpart to the bulk goods radar, the NivoRadar NR 7 (photo, left) has been designed for processes in the liquid sector and, due to its design, is particularly suitable for acids and alkalis. Hall A4, Stand 117 — *UWT GmbH Level Control, Betzigau, Germany*
www.uwtgroup.com

Characterizing powders, catalysts asorbents and more

This powder-characterization company is focusing on the industrial value and application of its FT4 Powder Rheometer (photo), with many case studies being presented at the stand. The company has a joint booth with parent company Micromeritics, offering visitors a complementary opportunity to see new products, such as the AutoChem III and the Breakthrough Analyzer. The AutoChem III is an advanced platform for fast, safe, and precise catalyst characterization, while the Breakthrough Analyzer is a highly efficient system for assessing adsorbent performance under process-relevant conditions, as required for applications such as carbon capture and energy storage. Hall 3, Stand 532 — *Freeman Technology Ltd., Tewkesbury, U.K.*
www.freemantech.co.uk ■

Gerald Ondrey

Gas Dispersion in Liquids

Department Editor: Scott Jenkins

Injecting gases through a diffuser into a liquid is an important aspect of many operations in the chemical process industries (CPI). Important applications include dissolving reactant gases into a liquid phase for further reaction (such as in hydrogenation, oxidation, ozonation), as well as carbonation of beverages, stimulation of fermentation processes (Figure 1), aeration of wastewater for treatment, stripping of air or oxygen from chemicals, stripping volatile organic compounds (VOCs) from liquid chemicals, removal of moisture from fuels and others. This one-page reference provides information on key aspects of gas diffusion in liquids, including mass-transfer rate, agitation effects and equipment selection.

Mass transfer

The main purpose of a sparging system is to increase the gas-to-liquid mass-transfer efficiency, (a ratio of the amount of active gas component dissolved in liquid to the amount of gas injected). Low mass-transport efficiency leads to an elevated gas-injection rate. In this case, the increased gas volume raises the cost to achieve the desired results. The gas-to-liquid mass-transfer efficiency is primarily controlled by the mass-transfer resistance of the liquid phase.

Fast and efficient mass transfer is correlated with fine bubble propagation, which increases the gas surface area in contact with liquid.

Engineered porous metal or ceramic materials create fine bubbles according to the requirements of the application. Porous materials allow large volumes of gas to be passed with very high specific area. For example, with equal volumes of gas, 1-mm bubbles would have 6.35 times more gas-liquid contact surface area than 6.35 mm (1/4-in.) bubbles [2].

The gas-to-liquid mass-transfer rate per unit volume is calculated using: K_La (C^* – C), where K_L is the liquid-phase mass-transfer coefficient that is dependent on the diffusivity, liquid viscosity, temperature, and mixing; a is the interfacial area of gas bubbles in contact with liquid; C^* is the saturated concentration of the gas in liquid; and C is the concentration in bulk liquid.

By sparging small gas bubbles with high surface-to-volume ratio into the liquid, the interfacial area a is increased and the gas mass-transfer rate is improved. The mass-transfer driving force (C^* – C) also has a big impact on the gas dissolution rate, as the high-purity gas is used instead of the lower-purity gas. For example, the saturated concentration of oxygen in water from pure oxygen is five times higher than that from air, resulting in a large increase in the oxygen dissolution rate with pure oxygen.

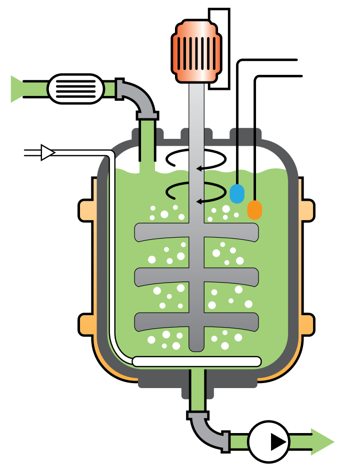


FIGURE 1. In an example of a gas-sparging application, a diffuser bar at the bottom of the tank releases oxygen to stimulate a fermentation process

Gas diffuser considerations

Spargers are chosen based on the design and operating conditions of the process The type and configuration of the sparger used depend on factors such as whether a process is a continuous process or batch, as well as the gas flowrate, tank size, mechanical agitation, operating pressure and temperature.

Materials of construction. Metal spargers are used in high-temperature, corrosive or oxidizing conditions, whereas ceramic spargers are sufficient for mild conditions.

Gas exit velocity. The gas exit velocity at the sparger surface is an important design criterion for sparger selection. The actual gas volumetric flowrate for exit velocity is calculated using the pressure (P) that is the sum of tank headspace pressure ($P_{Headspace}$), liquid head pressure at the sparger (P_{Liquid}), and pressure drop across the sparger element (ΔP). The minimum sparger surface area is based on the gas exit-velocity limit for the process.

The exit velocity limit is lowest for the static sparging operation when there is no mechanical agitation of the liquid phase. For agitated tank sparging and dynamic sparging, where liquid has high forced velocity along the sparger surface, the gas exit-velocity limits are significantly higher, requiring smaller spargers for the same gas flow. The exit-velocity limit for agitated tank sparging and dynamic sparging depends on the impeller speed and liquid velocity, respectively.

Agitation effects. Apart from using a properly designed sparger, it is important to focus on the mixing of gas and liquid. In chemical process applications, the reactor vessel is often closed, so that the unreacted high-purity gases, such as hydrogen or oxygen, are not vented through the system. In these applications, specially designed mixing impellers are used, depending on the operating conditions of the reactor. Typically, one impeller turbine is located above the sparger to shear and disperse the gas bubbles. Agitation at the liquid surface may also be required to entrain the headspace gas into the liquid phase.

Diffuser sizing. The size of a sparger depends largely on the superficial gas exit velocity from the porous sparger surface. This value is calculated from the actual cubic feet per minute (ACFM) per square foot of sparger surface area (ACFM/ft^2). The ACFM is calculated at the liquid pressure and temperature found at the sparger (the ACFM is not based on gas pressure)*. ■

Editor's note: Portions of the text in this column were adapted from the following article: Air Products Inc., Gas Sparging, *Chem. Eng.*, September 2012, p. 21.

*An additional reference is the following publication: Mott Corp., Gas-liquid Contacting Part Selector and Design Guide, www.mottcorp.com.

Downcomer Unsealing: A Correct Diagnosis Brings a Correct Cure

Henry Kister shares lessons learned from troubleshooting distillation towers

Following a distillation conference hosted by a simulation vendor, the delegates were transported by bus to a venue where the simulation vendor hosted a delicious barbecue. A gentleman sitting next to the author introduced himself. After exchanging a few greetings, he asked:

"Do structured packings work in the wash section of an atmospheric crude tower?"

"They do as long as you have good liquid and vapor distribution and they do not plug," I replied. "Some refiners swear by them. They experience occasional plugging episodes, but are comfortable living with them."

"I was afraid you'd say that. We have to put these in the wash section of our tower."

"Why? What is wrong with trays?" I asked.

He replied, "Trays just do not work for us. We are struggling with dark gas oil" (the presence of dark oil indicates poor separation in this section).

"Did the trays ever work for you?"

"At one time they did. But not any more," the gentleman replied.

That reply got my attention and I inquired further, "You went up in rates and then ran into a bottleneck?"

"Not really. We have always run 50,000 bbl/d [barrels per day] crude," he responded.

"This is getting interesting," I said.

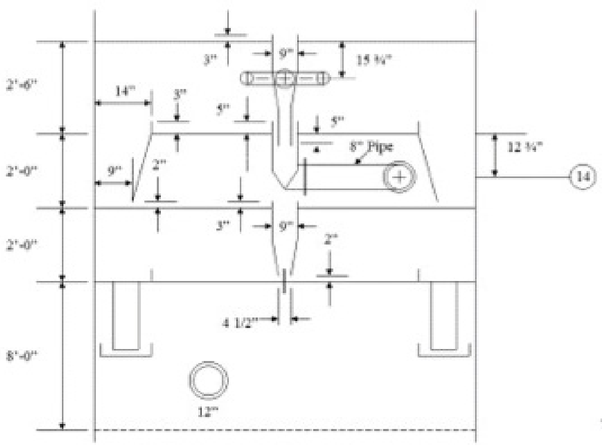


FIGURE 1. This is the initial setup of the crude tower wash section

"Why would trays all of a sudden stop working?"

"If you really want to know, I will be happy to tell. At one time, trays worked for us." Referring to a drawing showing the tray details (Figure 1), the gentleman explained: "The 12-in. nozzle at the bottom is the tower feed. Nozzle 14 is the atmospheric gas oil (AGO). It is a total draw. Reflux is pumped on flow control and returned above it. We ran 1,000 bbl/d reflux, which is about 2% of the crude feed."

"I would not complain about this. This is a 1–1.5% overflash on the crude, which is excellent. You won't do much better with packing," I said.

"Yes, but those days are gone and we cannot get back to them."

"Why?" I asked.

He explained further: "About six years ago we had a vendor make improvements to our tower. They were alarmed by the small feed nozzle, so they enlarged it from 12 to 24 in., and added a vane vapor horn distributor on it. They also added splash baffles on the trays to make sure they do not dry up, and downpipes on the spent wash to avoid re-entrainment [Figure 2]. When we came back on line, we needed to go to 6,000 bbl/d reflux to get the AGO on-color. Actually, once it got on-color, we could cut the reflux down to 1,500 bbl/d. But if we went down below this, it would go dark and we will need to go up to 6,000 bbl/d to get the AGO back on-color."

He continued, "We complained to them. They then reconsidered the vapor horn, and in the next turnaround removed it. They also changed the trays. The ones we had before were the Venturi moving valves that have smooth orifices and give low pressure drops. They were concerned that these trays will excessively weep, and changed them to moving valves with sharp edged orifices [Figure 3] that are more weep-resistant."

"Did this improve things?" I asked.

"Quite the contrary. Now we cannot get the AGO on-color, even if we run a reflux as high as 15,000 bbl/d. We went to different vendors. They all say we need structured packings."

I replied, "There are many towers that have trays working in the wash zone. And the trays worked for you at one time. What I believe you need is troubleshooting to find why the current trays are not working. I smell a downcomer unsealing problem, but need to take a close look at the dimensions and do a few sums."

"If you can find a way to keep trays, you will be a hero. But you'd better come up with a good proof that trays will work, because most people in our refinery, including management, are believing the vendors and have given up on trays," he said.

Once we drew the sketches to scale, the problem became apparent. The 2-in. clearance under the center downcomer was just too large for the low liquid rates experienced in the wash section, that typically operates at very low liquid loads. With this large clearance, vapor would break through into the downcomer. With the splash baffles 1.5 in. away from the weirs, and with the draw pan restricting the vapor exit from the center downcomer, the vapor breaking into the downcomer would not allow the liquid in. The middle tray would flood, and the bottom tray would not receive liquid and dry up. There would be no separation, and the AGO would go dark.

The problem was introduced by adding the splash baffles. The vendor was right about the Venturi valves weeping. This weep was actually beneficial, as it allowed the liquid a path downwards by weeping through the valves. Once enough weeping occurred, it would seal the

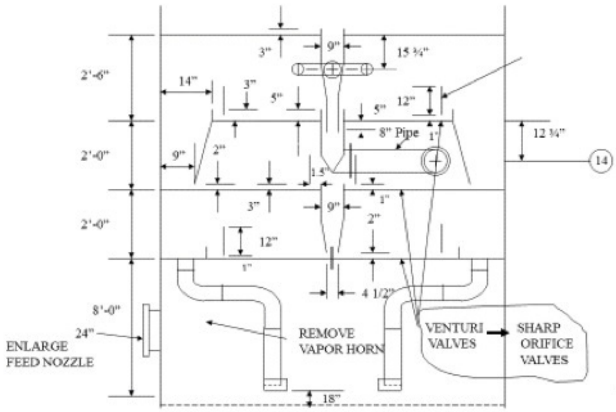


FIGURE 2. The diagram shows the first set of modifications

center downcomer, preventing vapor rise through it. This happened at about 6,000 bbl/d reflux. Once the downcomer was sealed, they could go back down to 1,500 bbl/d.

In the next revamp, the Venturi valves were replaced by the sharp-orifice valves that are resistant to weeping. Without weeping, there was no way for liquid to go down, so even increasing to a reflux of 15,000 bbl/d would not bring the AGO into specification for color.

After my explanation, the gentleman asked, "Nice theory, but can you prove it?"

"Absolutely. We can run a test that will get your AGO on-color. You will need to reduce the charge rate to lower the vapor velocity in the downcomer and allow liquid to descend. We will need gamma scans to watch for liquid in the center downcomer."

We proceeded with the test in which we used gamma scans to continuously watch the center dowcomer. Initially, the center downcomer contained vapor, no seal. Then when the charge rate was sufficiently reduced, the gamma scans saw liquid in the downcomer and the AGO came into specification for color.

At the next turnaround we removed the splash baffles and installed inlet weirs. We also made some modifications to the AGO draw. After this, the tower operated at a wash rate down to 700–800 bbl/d with the AGO always on-color.

The takeaway: When the patient's health suddenly deteriorates for an obscure reason, always go back to the last time the patient was well, and investigate all changes from then on. ■

Edited by Dorothy Lozowski

About the Tower Doctor

"The Tower Doctor" is the honorary title bestowed upon the author of this article in 2002 by Richard Darton, professor of Engineering in Oxford University and chair of the European Distillation Network. "When a tower is not well," says Darton, "people call Henry to diagnose the illness and find a remedy. He arrives with his doctor's bag, examines the patient-tower, measures its temperature and pulse, gets radiography to get an inside look. Then comes his diagnosis and cure. Towers treated by Henry mostly get better very quickly."

Being son to two medical doctors who were blessed with phenomenal diagnosis ability, the author aspired to live up to this special honorary title. Like with medical doctors, some illnesses were a struggle to diagnose, others were easier. All were exciting. This column will reminisce through some of the more entertaining cases. They may not have seemed entertaining at the time, but looking back at them, they leave unforgettable memories and raise a smile or two. One great aspect of being a tower doctor, one gets to work with and learn from some of the greatest engineers and operators that contributed so much to the chemical industry. We hope that this column can pass some of the fun, excitement and lessons learned to future troubleshooters and tower doctors.

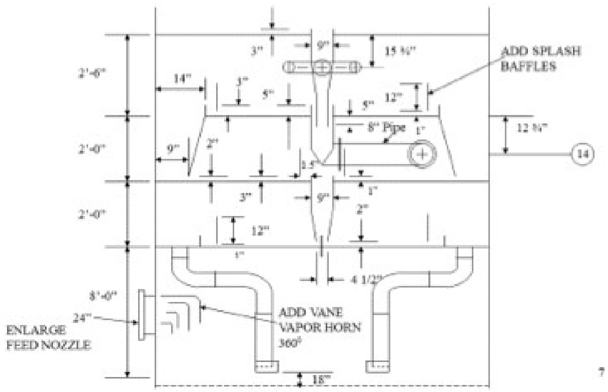
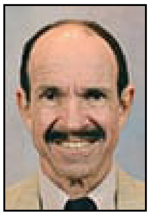


FIGURE 3. The second modifications to the atmospheric crude tower wash section are shown here

Author



Henry Z. Kister is a senior fellow and the director of fractionation technology at Fluor Corp. (3 Polaris Way, Aliso Viejo, CA; Phone: 949-349-4679; Email: henry.kister@fluor.com). He has over 35 years of experience in design, troubleshooting, revamping, field consulting, control and startup of fractionation processes and equipment. Kister is the author of three books, the distillation equipment chapter in Perry's Handbook, and over 130 articles, and has taught the IChemE-sponsored "Practical Distillation Technology" course more than 530 times in 26 countries. A recipient of several awards, Kister obtained his B.E. and M.E. degrees from the University of New South Wales in Australia. He is a member of the NAE, a Fellow of IChemE and AIChE, and serves on the FRI Technical Advisory and Design Practices.

Burner Technologies and Concepts: Meeting Emissions-Reduction Goals

To meet bold sustainability targets, new burner technologies and control configurations are being developed to help significantly reduce NOx emissions

Jonathan Stoeger
Cleaver-Brooks

IN BRIEF

NOx TYPES

FUEL STAGING

INDUCED FLUEGAS RECIRCULATION

HIGH EXCESS AIR

TWO-STEP COMBUSTION

ADVANCED CONTROLS

POST-TREATMENT SOLUTIONS

THE FUTURE OF COMBUSTION

Many industry-leading businesses have set bold sustainability goals for emissions reduction and energy efficiency driven by factors such as climate change, the Paris Agreement and various national, state and local regulations.

In the U.S., California has always led the way in emissions reduction. It was the first state to mandate an emissions standard of 30 parts per million (ppm) for oxides of nitrogen (NOx), which subsequently decreased to 15 ppm NOx and to then just 9 ppm NOx. Now, some counties in California are enforcing a 2 ppm NOx requirement on larger industrial watertube (IWT) boilers. Other states will be following suit with 30 ppm or even lower NOx emissions requirements.

The boiler industry continues to introduce advanced technologies and solutions that reduce both NOx and CO emissions (Figure 1). Today, there are various combustion technologies and firing styles, depending on application, fuel and firing size, that are available for traditional and renewable fuels. These newer offerings coupled with advanced control systems ensure high turndown, a consistent fuel-to-air ratio and repeatability in combustion.

Turndown is a concept that is important to understand. Regarding boiler systems, it is a ratio that identifies a system's high-fire and low-fire settings. For example, a 100-million Btu/h burner with 10:1 turndown will reach high fire at 100 million Btu/h and low fire at 10 million Btu/h. The main benefit of high turndown for a boiler system is reduced cycling, which reduces the energy consumption and thermal stress of a boiler.

By reducing cycling, less fuel is needed and fewer emissions escape into the atmosphere. Turndown is highly dependent on the burner design. Many high-turndown burner systems require an advanced control system — typically, these either involve parallel positioning or fully metered systems.

NOx types

It is first critical to understand that there are three different types of NOx.

- Thermal NOx is based on temperature and makes up most of the NOx formed during combustion
- Prompt NOx is formed when molecular nitrogen in the air combines with the fuel in fuel-rich conditions
- Fuel-bound NOx is based off nitrogen in the fuel and is a natural occurrence during combustion

The type of NOx that is reduced most with burner technology is thermal NOx. This can be achieved by lowering the temperature of the flame or by eliminating prompt NOx, some of which can be reduced by optimizing the fuel-to-air mixture in the burner. There are different types of burner technologies

FIGURE 1. Lower NOx and CO emissions requirements are forthcoming, and burner technologies are evolving to help achieve these goals

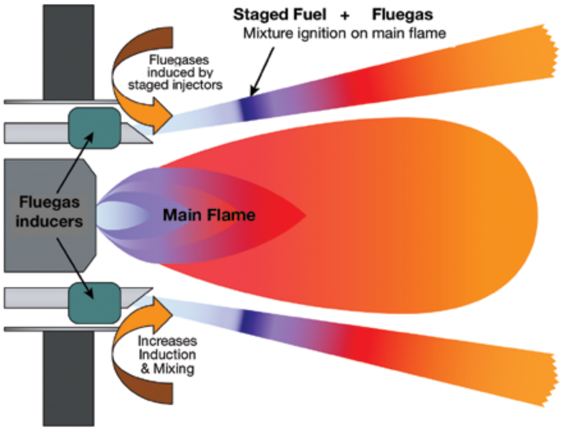


FIGURE 2. Fuel staging with fluegas inducers involves injecting a portion of the main fuel into the furnace prior to ignition, which serves to dilute the fuel with gases, effectively lowering the flame temperature and inhibiting NOx production

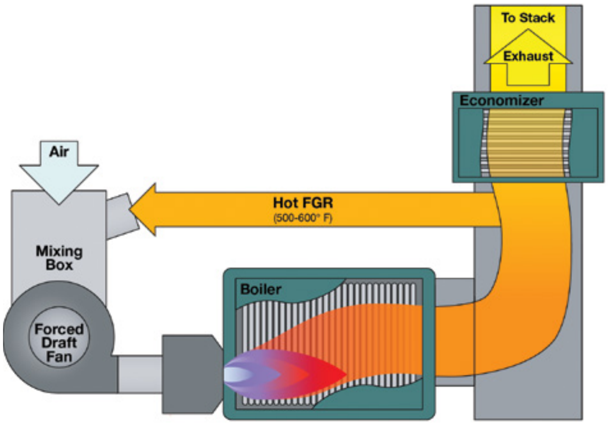


FIGURE 3. A typical firetube boiler with fluegas recirculation (FGR) is shown, where the hot recirculated gas stream is diverted before reaching the economizer

and combustion systems that can be implemented today, and each one has its own characteristics to reduce NOx and increase efficiency. These methods include the following:

- Fuel staging
- Fuel staging with fluegas inducers
- Fuel- and burner-induced fluegas recirculation (FGR)
- High excess air
- Two-step combustion (fuel and air injection)
- Selective catalytic reduction (SCR) can be added on these technologies to reduce a plant's emissions and NOx

Fuel staging

Fuel staging injects a portion of the main fuel to mix with combustion gases in the furnace prior to ignition (Figure 2). Thus, it dilutes the fuel with gases, primarily N_2 and H_2O. Staging the fuel in this manner causes it to ignite off the main flame, and the volume decreases the amount of radiant-heat transfer of the furnace. This radiant-heat transfer helps to cool the flame. Combustion of these two effects reduces the flame temperature, thus lowering the NOx formation.

Behind the process, some of the gas injectors on the outer side of the combustion head (or perforated

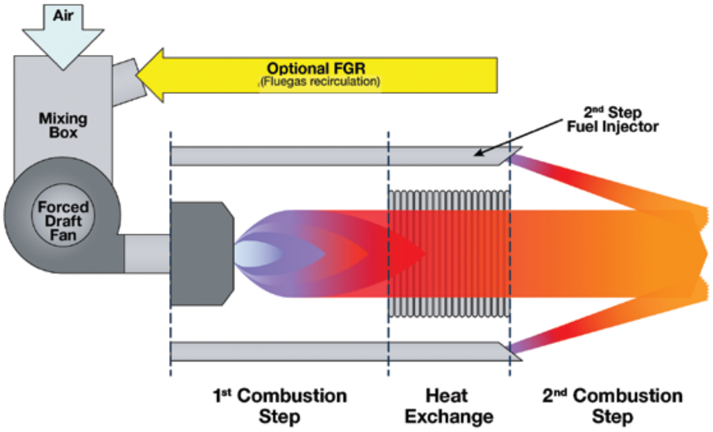


FIGURE 4. The first step in the fuel-injection method involves high excess air and heat transfer

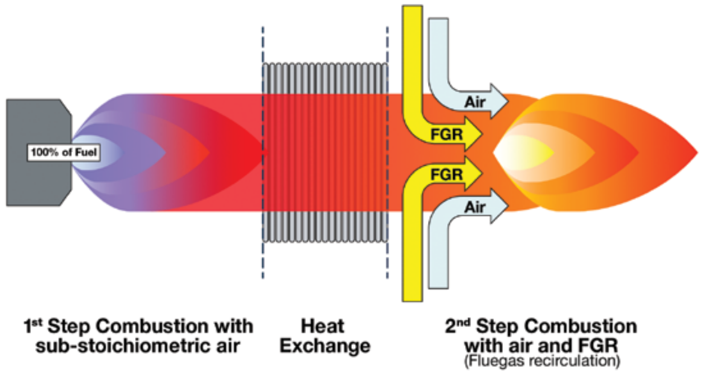


FIGURE 5. The air-injection method begins with sub-stoichiometric combustion

portion of the head) have a single, large grill in them, called staged injectors. These injectors direct the fuel jets on the outside of the main flame combustion.

Larger injection orifices produce larger jets that travel further into the furnace itself. Mixing more slowly before igniting on the main flame produces a larger flame envelope that helps to increase the radiant heat transfer. More heat transfer from the boiler to the furnace and into the flame itself yields more heat and increases NOx emissions.

Fuel staging by itself can reduce NOx by about 20–25%. For example, for a 100-ppm NOx standard uncontrolled type of burner with fuel staging in place, NOx emissions can be reduced to 75–80 ppm.

Induced fluegas recirculation

Induced fluegas recirculation (FGR) is one of the most common and efficient methods to reduce thermal NOx (Figure 3). The process takes cool, inert fluegas and mixes it with combustion air to increase mass flow through the flame front, thus reducing the temperature and thermal NOx formation.

Figure 3 demonstrates how the fluegas is pulled out before it reaches the economizer. On a small firetube with higher temperatures, recirculated fluegas will be pulled off and mixed with the air. From there, with the fan, it will be introduced and mixed with the fuel into the combustion process. This will minimize the flame temperature to reduce thermal NOx and lower burner emissions.

This technique is used in many combustion engines today. It can be called exhaust gas recirculation (EGR). Basically, it is a simple solution. By adding a little water, the system cools down. It can be likened to putting fluegas in the system to help cool down the flame and keep NOx emissions low.

For larger-capacity boilers, such as IWTs, FGR will typically be taken off after the economizer. On larger boilers, it is preferred to have slightly cooler temperatures for FGR.

NOx can be reduced by 90% when utilized with other burner technologies. With internal technology, 9–10 ppm NOx is achievable when combining multiple technologies. Today, even 5 ppm NOx is achievable in certain circumstances.

High excess air

The high excess air method increases the mass flowrate of excess air to cool the flame, similar to the FGR solution. To be effective, it is necessary to control the flame-front position. Also, it is very important in this method for the fuel-and-air mixture to be premixed prior to burner ignition. Otherwise, the flame will move up and flow into a fuel-rich condition. Once that happens, the burner will go into displacement, and the flame temperature will start to rise again, counteracting the benefits of premixing.

Because the fuel and air mixture must be premixed and control of the flame position is required, a high excess air strategy can only be used with certain types of burners.

Utilizing this type of technology, NOx can be reduced to 7.5–9 ppm. A major benefit of high excess air is achieving low emissions without utilizing FGR.

Two-step combustion

The last of the combustion technologies is two-step combustion, of which there are two types: two-step fuel-injection and two-step air-injection. The processes are somewhat similar with the main difference being that two-step fuel injection utilizes a lean premix combustion in the first step, and in two-step air injection, the first step involves a very fuel-rich combustion.

The first step in the fuel injection method consists of high excess air and heat transfer (Figure 4). All of the combustion air goes through the burner, whereas only a portion of the fuel ges goes through, which results in very lean combustion.

In the second step of the combustion process, additional fuels are injected into the combustion products. For this to be effective, some amount of heat must be removed prior to the first step and before subjecting the second step to fuel. The heat generally can be removed by a radiant heat exchanger to the furnace walls.

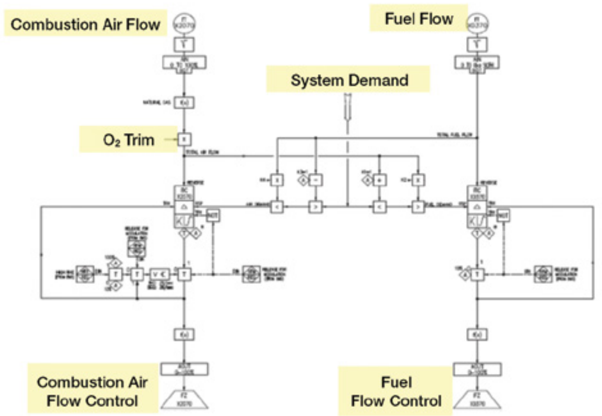


FIGURE 6. This fully metered control system includes cross-limiting capabilities and individual device actuators

During the first step, the combustion reduced to flame temperature between the heat exchanger is insufficient. FGR can be added to the first-step combustion to reduce the flame temperature itself. The fuel injected in the second step may be staged to blend it with furnace gases and fuel station of the second fuel injection step, which is common for this system.

The typical packaged boiler using a two-step fuel-injection system achieves around 30 ppm NOx without FGR. If FGR is added to the two-stage injection process, NOx can be reduced to 9–10 ppm.

Applying the two-step air injection method to very large furnaces, such as field-erected boilers, requires two combustion systems because of the sheer volume required.

In the air-injection method (Figure 5), the first step is a very rich, or what is called sub-stoichiometric, combustion. In this type of combustion, there will be only partial combustion in the first step.

In the second step, the rest of the combustion air is introduced, and usually the heat transfer between the two injection steps is not sufficient to reduce the temperature. Therefore, FGR has to be introduced in the second injection step along with air.

The second combustion step is responsible for most of the thermal NOx production, so it is important to control the temperature of the flame. In the field, this is often referred to as over-fire air on field-erected boilers. By utilizing the two-step air-injection method, NOx can be reduced to 30 ppm. With Number 6 oil (a high-Btu-content residual oil), NOx can be reduced to 140 ppm, whereas it normally would be around 375 ppm.

Advanced controls

To utilize these combustion technologies or processes, advanced controls, such as parallel positioning systems or fully metered systems, are required. Additional options include variable speed drives (VSD) and O_2 trim airflow-trimming systems (described in the upcoming section). These systems provide precise control, which is needed to control the fuel-to-air ratio and achieve a good mixture with the firing technologies.

Parallel positioning. Basically, parallel positioning is a control system that optimizes the burner's fuel-to-air ratio. There are many benefits of utilizing a parallel positioning system instead of a standard, single-point position.

Parallel positioning provides precise fuel-and-air ratio control because there is an actuator directly coupled to the control valve, whether it be the air damper, gas metering valve or FGR valve to ensure repeatability. At all points in the combustion process, it is always going to repeat.

Parallel positioning utilizes dedicated servos that are high-resolution actuators, and each one of the fuels or air has its own dedicated servo. The air damper has its own dedicated servo. The gas control valve has its own dedicated servo, and if FGR is present, there is a servo on the FGR valve that will control the amount of recirculation. Every actuator is also equipped with a feedback signal to improve safety. If an actuator does not reach its position, it will signal an alarm and shut down.

Each of these can have its own separate curve that will be applied. The air-fuel curve for parallel positioning is a software function. Because of that, it is possible to modify a curve or even have multiple curves for the fuels to meet the requirements for the various burner technologies. Also, because it is a software function, there is the capability of adding a variable-frequency drive (VFD), VFD bypass and O_2 trim systems.

Since high-resolution actuators are used, there is

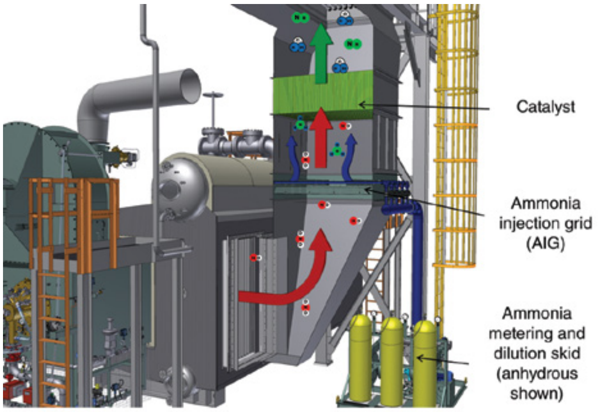


FIGURE 7. A selective catalytic reduction (SCR) system is used to further reduce emissions downstream of combustion processes

good combustion throughout the entire modulating process of the burner. And, a big benefit is there is less hysteresis loss. Because of this, expect fuel savings of about 2 to 3%. This fuel savings means less fuel is being burned, which translates to fewer emissions going into the atmosphere.

By utilizing an advanced control with a newer combustion firing technology, NOx emissions can be reduced to 9 ppm or, in some cases, as low as 5 ppm.

Fully metered systems. A fully metered system is the preferred method used to accommodate air and fuel pressure or temperature changes in a firing-rate control system. To graduate from a parallel positioning system is to go to a fully metered system with cross-limiting capabilities (Figure 6).

Similar to a parallel positioning system, a fully metered system uses individual device actuators. The primary operational difference is that a parallel positioning system uses the position of the air- and fuel-control devices as indications of proper flow, and a fully metered system uses flow sensors to monitor the actual air and gas fuels flow. Additionally, while it is monitoring, a fully metered system will adjust the control devices as necessary to achieve the desired flow.

A fully metered system is used to create the air and fuel setpoints against which the respective flows are prepared to create the flow control position air signals. Using an O_2 trim system is highly recommended with this type of system.

A fully metered system with a cross-limiting firing control has the highest efficiency and best emissions control of all the systems in use today, because it comes with air and fuel meters enabling flow indication and totalization.

In addition, a fully metered system has the potential for pressure and temperature compensation. It also is compatible with multiple-burner applications and alternative fuels. It can do simultaneous firing with different types of fuels safely, efficiently and reliably. Both federal and local regulations often require fuel totalizers, and this fuel metering system includes those.

O_2 trim. O_2 trim is an option that maintains excess air at a desired level in a combustion system. It compensates for small variations in the fuel-to-air ratio caused by operating conditions. Variations include atmospheric pressure changes, temperature changes, or just mechanical wear and tear of the burner and components themselves.

Remember, one thing about burner combustion is that anything that can impact air or fuel flow will impact burner performance, which negatively impacts emissions.

The O_2 trim option requires an O_2 sensor that is installed in the fluegas outlet, up in the stack of the boiler. It gives a feedback signal to the combustion control system.

The system maintains the optimal O_2 combustion to achieve NOx targets with good, complete combustion. This is both a performance factor and safety factor. Having O_2 trim prevents the combustion from getting too rich or falling below 1% O_2. On some burners, it is critical to not exceed 8–9% O_2 during combustion.

O_2 trim is also a very effective way to identify a potential problem. If O_2 levels start increasing, O_2 trim systems will reveal it.

Additional benefits of O_2 trim are efficiency and reliability. Basically, the control ensures fluegas O_2 consistency, better combustion and fuel-air corrections in conjunction with air temperature changes, all of which result in fuel savings of about 2–3%.

VSD. Another option is installing a variable speed drive (VSD) on the fan that improves the ability to control combustion air, especially if the fan is oversized. With better air control, there is more control of the fuel-air ratio, which translates into better, more accurate, more efficient combustion. And, by doing that, low and ultra-low NOx emissions can be achieved.

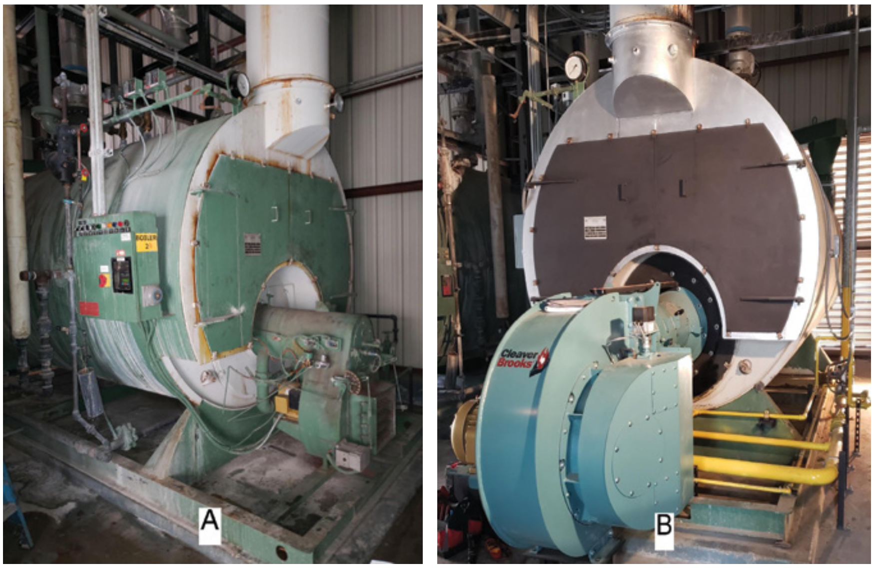


FIGURE 8. Replacing a legacy burner (A) with a new low-NOx burner (B) helped this plant to reduce NOx emissions from 90 down to 24 ppm. Also, cycling and excess air were reduced, increasing overall efficiency and reducing fuel usage by 10%

Post-treatment solutions

A selective catalytic reduction (SCR) system can help reduce NOx emissions by as much as 94%. For instance, if a facility has an uncontrolled burner with 100 ppm NOx, an SCR system can reduce emissions to 6 ppm NOx. Another benefit with SCR systems is that by utilizing some of the burner technologies above, less catalyst is required.

On a 30-ppm burner, 5–6 ppm NOx is achievable with SCR, while using less of the catalyst. This solution works with any fuel if the fluegas temperature is within the 400–700ºF range. In this temperature range, the catalyst exhibits its highest level of activity. The catalyst bed can be designed for small to very large exhaust flowrates of millions of columns per hour, and ammonia injection can be varied to accommodate various fuels for multiple-fuel- and simultaneous-firing applications.

Note that there are a couple of limitations with SCR. One is that fluegas flow cannot contain too much particulate matter. Otherwise, the catalyst will plug up quickly. There are different catalyst pitches that can be used to mitigate this problem. Also, the catalyst can be deactivated in the presence of certain substances, such as catalyst poisons.

Also, because ammonia is a base, the fluegas acid concentration must be monitored closely on this type of system. Below the acid dewpoint, ammonia will combine with an acid to form a salt, which can plug the catalyst itself. Figure 7 illustrates how an SCR system works to reduce emissions and NOx.

In an SCR system, the reaction to ammonia with NOx will occur naturally at high temperatures, around 1,600˚F. This reaction decomposes the NOx, NO and NO_2 into harmless water and nitrogen gases.

The introduction of ammonia in the boiler system adds a new emission that has to be contained — ammonia slip. This is the unreacted ammonia that finds its way through the SCR system.

Stack ammonia slip limits are usually between 2 and 10 ppm. Because of the slip limit, the ammonia flowrate needs to be precisely controlled to match NOx flowrate. This function is controlled by an ammonia flow-control unit. Also, to minimize ammonia slip, the ammonia injection pattern needs to match that of the NOx distribution pattern.

This function of the ammonia is part of the ammonia injection grid. As the exhaust gas flows through, the ammonia flow-control monitors the amount of ammonia going into the ammonia injection-grid area. Inside, it is mixing with the exhaust gases, going through and out of the catalyst. Again, with SCR, N_2 and H_2O are the byproducts.

The future of combustion

The boiler industry will continue to strive to decrease NOx emissions. In addition to reducing NOx emissions, there is emphasis on reducing the carbon footprint.

In the near future, look for technologies to be implemented within these combustion cycles to not only reduce NOx emissions, but also to reduce the amount of carbon output from the combustion process. Carbon-capture systems and other technologies are gaining more traction.

Another focus for our industry is energy efficiency. Higher efficiency equipment utilizes heat better, which naturally reduces the amount of fuel needed to be burned, and hence, emissions (Figure 8).

Lastly, there is also big focus on engineered and renewable fuels, especially on the hydronics side. Renewable fuels have less emissions byproduct, which is helping many companies today achieve their targeted sustainability goals. ■

Edited by Mary Page Bailey

Further reading

1. Achieving Balance in Combustion, *Chem. Eng.*, August 2022, pp. 14–17.
2. New Ways to Achieve Better Control of Emissions, *Chem. Eng.*, January 2021, pp. 12–15.
3. Low-Cost Techniques for NOx Reduction, *Chem. Eng.*, May 2020, pp. 30–36.
4. Enclosed Combustion Equipment and Technology, *Chem. Eng.*, January 2018, pp. 46–49.

Author

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Selection Guide for Solids-Drying Systems

Information provided here offers a basic primer on the features and functions of dryer types, with a focus on fluidized-bed dryers, for moisture control in industrial operations

Lance Briggs
Kason Corp.

The ability to control the moisture of solid materials while drying plays a critical role in the chemical process industries (CPI), including agriculture, chemicals, plastics, pharmaceuticals and others. Almost every plant that handles powders or granules requires a dryer of some type within the facility, and the challenge becomes which type of dryer will best suit a particular application and the specific material to be dried? This article is a basic primer on the features and functions of different dryer types, and aims to help in the selection of the right dryer for specific moisture-control applications.

The two overarching categories for dryer types are direct and indirect dryers. A direct dryer uses hot air as the mechanism of water evaporation. An indirect dryer uses rotating heat surfaces to transfer heat into the wet material.

Of these two types, the most common is the direct-style dryer, in which natural gas is used as the fuel to heat the air. However, no single dryer suits every application. An examination of the various features can help determine which type of direct dryer will best suit a given set of specifications.

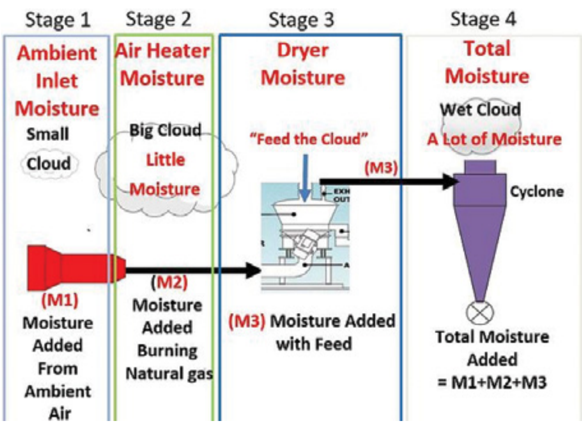

FIGURE 1. The four main stages for a direct-drying system are shown here

Dryer design: 'weather system'

A deeper understanding of the direct-drying process can be obtained by assuming the role of fluidized-bed "meteorologist" to model the air and moisture properties during various stages of the drying process. Figure 1 depicts the four stages of a direct-dryer system.

Each stage illustrates a cloud formation, with the shaded areas representing the relative amount of water vapor, the cloud's expansion and absorption of water vapor during each of the four stages. A psychrometric chart helps model the process.

Stage 1 shows the inlet with the ambient moisture (amount of water vapor per unit of dry air) coming into the dryer. The cloud is small, reflecting the size and amount of water vapor present.

In Stage 2, the air is heated to the inlet air temperature. The greater the amount of heated air from the natural-gas air heater, the more the air expands, enabling it to carry away more water vapor. This may be perceived from the psychrometric graph as well. Heating the air increases its temperature and is depicted by a horizontal line in the graph. While the total water content remains unchanged, the ability of air to hold moisture significantly increases. In other words, the relative humidity decreases as we heat the air. Depending on the inlet air temperature, the specific volume of air may double. Some additional water vapor is added to the cloud by burning natural gas.

Stage 3 illustrates the screw feeder dumping moisture-containing solid product into the dryer, thereby "feeding" the cloud.

In Stage 4, the moist air is expelled from the machine as the cloud cools and contracts, while still retaining the water vapor from the prior stages. The relative percentage of moisture in the outlet air can be measured by its relative humidity, the percentage of actual vapor pressure divided by saturated vapor pressure, or the adiabatic saturation ratio (ASR), and the percentage of the actual weight of water vapor over the weight of saturated water vapor.

While some may be more familiar

BACKMIXING

When comparing fluidized-bed dryers to other technologies, one key process — backmixing — is often overlooked. Backmixing is a process of feeding wet material into a dryer to mix with solid material that has reached or almost achieved its targeted moisture level. This practice facilitates the drying of the newly introduced wet material, in a way "priming" the newly introduced wet material, while also helping the nearly dried material to finish drying in a steady and even manner. Certain material types require backmixing.

Backmixing moves a percentage of dried material out of the drying system and slowly cycles in new wet material. In addition, it utilizes the power of osmosis to help the dry material absorb moisture from the wet. This speeds the drying process in a gentle way.

A circular style fluidized-bed dryer can supply continuous internal backmixing due to its circular design and due to the mechanics of how materials flow into and through it. A control panel connected to a gage inside the dryer measures key indicators such as internal temperature within the dryer, air entering and exiting the system and so on.

Backmixing can help in the following solids-drying situations:

- Help prevent an undesirable chemical reaction that could be stimulated by other drying processes
- More thoroughly dry sluggish or hard to fluidize materials
- Save energy by leveraging the heat existent in the resident material in the dryer to aid drying of newly introduced, wet material
- Decrease risk of material shock by reducing the absorption rate of heat for the resident material within the dryer
- Cools dried material prior to its exit from the dryer

with the concept of relative humidity, this measurement is more commonly used with heating, ventilation and air conditioning (HVAC) systems and is not as applicable at much higher temperatures. On a psychometric chart, the ASR is mathematically split into ten equal percentages. The ASR tops out at 100%. This means that at 60% ASR, it is possible to add 40% more water vapor to reach saturation.

Depending on the temperature profile, most direct dryers will fall within an acceptable range of 70 to 90% ASR and be able to attain the desired final product moisture.

The challenge with a direct dryer is maximizing the time the wet feed is in contact with the heated drying air. A checklist of major factors that will affect drying rates, efficiencies and features will impact the selection of the proper direct-drying system. These factors can include:

- Air flowrate
- Air flow direction
- Moisture content of materials
- Heat sensitivity (maximum allowable temperature)
- Layout
- Backmixing (see Box 1, p. 40)
- Agglomeration
- Particle range, size, color and shape
- Plant footprint
- Thermal features (other than drying)
- Sanitation
- Throughput
- Maintenance
- Special material considerations, such as explosive or combustible materials

Drying curve

Materials' drying curves show the reduction in moisture over time as the material is processed (Figure 2). Flash dryers supply a swift initial moisture reduction; however, they are not always the most effective in obtaining the lowest moisture content.

Reaching lower product moisture levels overall requires a longer exposure time to allow moisture to migrate out from the particle's center. For that reason, dryers with a longer residence time, such as a rotary, conveyor or fluidized-bed dryer, will give a more consistent, low-moisture-content result.

Solids processors might select a two-stage system that takes advantage of the complementary benefits of two different types of dryers; the short heat exposure of a flash dryer, followed by a longer term of exposure in a secondary dryer.

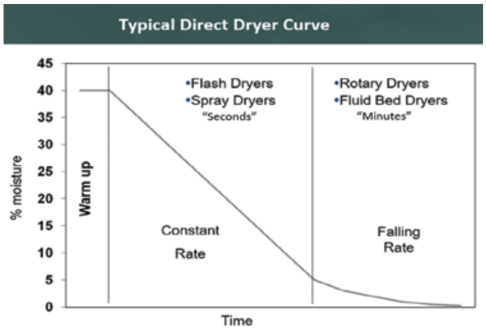

FIGURE 2. Flash dryers supply a rapid initial reduction in moisture content, but reaching lower moisture levels requires longer residence time

Temperature and testing

Ultimately, the only way to know precisely how a dryer will perform with a particular material is to perform testing. Typically, manufacturers will have a small laboratory test dryer, where it is possible to run small batches at different drying times and temperatures. After conducting tests in smaller dryers, the scale-up calculations take into account the retention time (determined by the volume of the bed and the flowrate of the solid material) to determine the heat and mass balance needed to scale to a larger dryer.

Heat loss of each dryer is individual, depending on the size and insulation of the dryer. For example, smaller dryers have a higher range of heat loss due to larger surface areas compared to airflow, amounting to up to 20% more heat loss compared to larger dryers. One of the advantages of relatively short retention direct dryers is the evaporative cooling effect as the feed material dries. For that reason, the "rule of thumb" of the inlet air temperature can be as much as 50ºC above the sticking point or degradation point of the material. The outlet air temperature (the temperature of the vented air after drying) is vital in con-

trolling the product moisture. Some dryer operators control the wet-bulb or the dewpoint temperature to control product moisture. The temperature and water-vapor loading of the outlet air stream will relate to the final product moisture.

Dryer types

Brief descriptions of various types of dryers used in industrial drying applications follow.

Rotary dryers. Rotary dryers are designed with rotating, tumbling drums and internal lifters that cause the moist solid to "rain" down through the passing and heated drying air. The challenge related to this dryer is maximizing the time the wet feed is exposed to the heated drying air: the better the contact, the shorter the rotary dryer's length and the lower the cost. Final design will depend on the retention time required.

Conveyor belt dryers. Conveyor dryers (also called belt, tunnel or apron dryers) are rotating belt conveyors typically equipped with a perforated belt to allow heated air to circulate through the belt and the wet feed. The challenge for this dryer is getting the heated air into contact with the inner layer of the feed on the belt. Some use multiple belts to reorient the feed and expose internal surfaces to the heated air.

Spray dryers. A spray dryer begins with a liquid feed or slurry, progresses to atomization of the liquid or converts it into smaller droplets. The goal is rapid drying of liquid material into a powdered material using heated gas. Many different types of spray dryers are available and commonly used within the food, chemical and pharmaceutical industries. Spray dryers often will be used in conjunction with a fluidized-bed dryer, as complementary systems to achieve the target moisture level.

Flash dryers. A flash dryer is a hot pneumatic conveyor. The challenge is to increase the exposure time from a few seconds. There are variations, such as recycling large particles or inline particle size reduction to aid in drying. Flash dryers are used in processing food or minerals that may be sensitive to prolonged heat exposure.

Fluidized-bed dryers

Fluidized-bed dryers use heated air to fluidize and dry feed material and are either static or vibrating in design. Static fluidized beds can have bed depths that minimize the size of the dryer and the amount of drying air required. The inefficiency of a direct dryer is the exhausted hot air; minimizing the amount of air increases the dryer's efficiency.

Fluidized-bed dryers come in two different shapes: rectangular or circular. Fluidized-bed dryers (and coolers) offer batch and continuous processing capabilities.

Rectangular versus circular fluid-bed dryers. A rectangular fluidized-bed dryer operates on a conveyor-style movement for material transport through the dryer. These can be built to higher capacities and with multiple stages. Rectangular fluidized-bed dryers offer a viable option for a high-volume, continuous application that does not require stringent adherence to rigid sanitation standards. However, the larger size requires a substantial plant footprint and can be a challenge to install, clean and maintain, with the largest sizes requiring a crane or forklift to maneuver.

One of the challenges for a rectangular fluidized-bed dryer is the "dead" areas in the dryer's corners that can trap or retain previously processed materials or harbor bacterial growth. In case of product or material retention, the material with a longer dwell time can overdry some materials. In food, pharmaceutical and similar applications, fast and thorough cleaning capabilities are critical to comply with 3-A, USDA, FDA, BISCC and other stringent sanitary and safety standards.

Circular fluidized-bed dryers offer both batch and continuous drying capabilities, with batch offering greater operator control of the final moisture level. In applications where the specifications are not as tight for final moisture levels or if they fall within a range, the operator can opt for a continuous drying process.

The circular design is free from internal corners or edges, offering easier maintenance and cleaning options than a rectangular version. A

GRANULAR CHEMICAL PROCESSING WITH FLUIDIZED-BED DRYER-SCREENER

A company processing a proprietary chemical substance comprised of a granular carrier material, a filler and an active ingredient needed to reduce the moisture level to less than 1% and screen with a discharge rate of 2,000 lb/h.

The company's engineering manager initially considered a rectangular fluidized-bed dryer, but found it both cumbersome and costly. The mechanism of action was acceptable. However, the size of the equipment in rectangular models would occupy twice the space of a circular fluidized-bed dryer, require massive infrastructure and ancillary equipment, and higher airflow, consuming a greater amount of energy.

Instead, the manager selected a circular fluidized-bed dryer. reduces the moisture content of converted material to less than 1.0% at 120ºF (49°C), after which the material feeds into a circular vibratory screener/separator that removes oversized agglomerates or undersized fines, discharging material at a rate of 2,000 lb/h.

Not only did it quadruple production of this proprietary granular chemical product, but it also improved quality by increasing the consistency of drying times and improved labor utilization. The plant manager reported a significant decrease in staff-related errors.

circular fluidized-bed dryer can often complete a cleaning cycle in an hour or less, while a rectangular fluid bed can take up to an entire shift.

Materials processed in a circular vibratory fluid bed move in a spiral motion, providing even airflow and vibration throughout the bed to separate and fluidize individual particles. This motion maximizes material surface area and drying, with the materials entering and exiting cleanly. This supplies a more homogeneous moisture level from batch to batch. The design allows for precise control of air temperature and airflow, bed depth, dwell time and material flow paths.

The design of the circular models offers an inherent strength to the operator ancillary benefits. Construction materials can be downgauged, vibratory motors downsized for quieter operations and associated components eliminated for a lighter machine. Of particular note, energy savings are significant, consuming 20 to 50% less power on average than a rectangular model when comparing similar throughput and while achieving similar moisture content.

Plant footprint is greatly reduced compared to a rectangular fluidized bed as well, which is significant when evaluating throughput per square foot of factory floor space (see Box on this page).

A vibrating fluidized-bed dryer can handle a much wider range of shapes, sizes and densities in addition to friable materials. This includes products within industrial manufacturing areas as diverse as the following:

- Wood flour
- Agricultural chemicals
- Fertilizers
- Catalysts
- Agglomerates
- Ceramic beads
- PVC powder
- Sodium maleate hybrid and similar materials
- Recycled plastics and glass

Concluding remarks

Industrial direct-dryer design takes into account a multitude of factors, and no single dryer a perfect fit for all applications. Educate yourself about different dryer functions and features when seeking the right equipment for your specific drying applications. Research available dryer types and be sure to analyze the conditions at any point of the four stages of drying to obtain the best understanding of a direct dryer. Pay particular attention to the temperature profile, retention time, airflow and moisture reduction capacity, as well as customization options for more unique drying situations. Most importantly, make sure to test your material on any style dryer being considered before getting an estimate. Vendors should be willing to accommodate this step in the dryer-evaluation process. ■

Edited by Scott Jenkins

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Rotary Drying: Developing a Process in a Test Setting

Testing not only illustrates proof of process and provides other critical assurances, but it also reveals the parameters necessary to reliably yield consistent results

Shane Le Capitaine and Carrie Carlson
FEECO International

Drying is an integral tool in pretreating and finishing bulk solids, which helps producers to meet quality and performance expectations, as well as lower their shipping costs. Designing and optimizing a drying process for efficiency is essential to minimizing operating costs and maximizing the production of a quality product, particularly when it comes to rotary dryers (Figure 1). As such, testing trials and process development are often a critical aspect of meeting dryer system expectations.

This article covers how dryer testing services can be used to optimize bulk-solids dryer design.

When is testing necessary?

Rotary dryer testing isn't always necessary, but it is almost always beneficial. Testing is often undertaken in an effort to do the following:

- Design a new commercial-scale drying operation
- Optimize an existing process
- Meet new target parameters
- Change existing process conditions or feedstock
- Retool a plant for a new purpose or product

Developing an efficient dryer designed around the specific process and product goals sets the stage for the life of the operation. Even if a standardized unit performs reliably, over time, small inefficiencies can add up to major costs, especially considering that rotary dryers are often in operation for decades.

In other cases, and particularly when developing a novel process, testing is a necessary step on the path to a commercial-scale operation. Testing reveals the process and equipment parameters required to achieve product quality and production goals with the specific source of feedstock. It also provides critical assurances that the commercial-scale system will perform as expected. When a thorough testing program is not undertaken, producers may find themselves faced with the following:

- Inability to reach rated capacity
- Experiencing a high level of attrition in the product
- Inability to reach target outlet moisture
- Struggling to achieve consistent product quality
- Experiencing frequent process upsets

Testing is particularly essential when working with materials that exhibit variation across sources, as this can make a material's drying behavior unpredictable. For this reason, testing is also likely to play a vital role as more producers begin to reconsider their industrial wastes and process byproducts as resources, drying them for reuse and recovery.

FIGURE 1. A rotary dryer is shown here

Process development

Developing or optimizing a drying process through testing can take many forms, depending on what is already known about the process and material, as well as the specific process and product goals. Most often, testing centers around one of the following objectives and progresses as necessary.

Showing proof of process. Since all materials can, in theory, be dried, initial testing focuses not on feasibility, but instead on confirming that the specific source material can be dried to the desired outlet moisture content, as well as identifying the basic parameters required to do so. In other words, initial testing is aimed at showing proof of process.

Testing at this stage identifies basic process criteria such as the following:

- Inlet and outlet temperatures
- Feedstock requirements (particle size distribution, moisture content, and so on)
- Retention time
- Percent fill

As part of the feedstock requirements, testing at this stage may also reveal the need for some type of pretreatment, such as particle size reduction, or further dewatering prior to drying.

Process and product optimization. Beyond this initial testing, further development focuses on fine-tuning the process parameters to optimize for product quality and overall process efficiency.

During this stage, more advanced process data points and their effect on the overall goals are explored and refined. This includes variables such as the following:

- Feed and product flowrates
- Rotational speed
- Drum slope
- Air flowrate (velocity)
- Air flow configuration (co-current or counter-current)

This stage of testing also gathers a variety of operating data that informs on process economics, requirements for off-gas handling and treatment, and other decisions. Data gathered at this stage often include such parameters as the following:

FIGURE 2. The flights used in a rotary dryer can be customized to match the requirements of a given application

- Exhaust gas flow
- Burner fuel usage
- System pressures
- Gas sampling and analysis
- Baghouse, cyclone, scrubber efficiency

Establishing optimal flight design. The flights, or material lifters employed in a rotary drum (Figure 2), create a cascading effect, or "curtain" of material across the drum's cross section. This maximizes the amount of contact, and ultimately heat transfer, between the material and products of combustion.

Flights are available in a range of standard and custom designs. Standard designs include straight, single-bend, and double-bend, among others.

In addition to flight design, the placement of flights throughout the drum, or pattern, is also highly customizable. It is not uncommon for flight design or pattern (or both) to change along the length of the drum, as process and material conditions change during the drying process.

Flight design is based around specific material properties, such as moisture content, angle of repose, potential for sticking and more, making this a very custom aspect of the design process. When flight selection is not readily apparent, a flight simulator can be enlisted in the testing process to identify the most suitable design for the material at given stages throughout the drying process.

A flight simulator is an offline rotating drum with flights that are easily changed out for testing. A clear end cap allows for visual observance of how the selected flights work with the material.

Targeting particle characteristics. Whether drying a finished product or an intermediary material, producers are often looking to target specific parameters in the material exiting the dryer. Testing provides the environment necessary to refine the process variables necessary to achieve those qualities. The most commonly targeted parameters during drying include the following:

- Outlet moisture content
- Level of attrition (product degradation)
- Bulk density
- Crush strength
- Particle size distribution (PSD)

By manipulating the design of the dryer, in combination with process parameters during testing, producers can reveal the conditions necessary to reach their target specifications.

The testing process varies depending on the user's goals, but it may also identify inefficiencies and opportunities for improvement, both in the process and the product.

FIGURE 3. A look inside a testing center, with a pilot dryer visible in the background

A case study: paper sludge

The paper industry has been under increasing pressure to find beneficial reuse applications for the sludge left over from the recycling process. In this effort, producers have begun drying their sludge for reuse in products, such as absorbents, cat litter, animal bedding, lawn products and more.

Depending on how the paper pulp was processed and dewatered at the plant, its characteristics, and particularly its moisture and clay content, can vary, making testing a critical step in developing a commercial-scale system. Optimizing for efficiency is especially important when working with wastes and byproducts, as the margin for profit is often slim.

Whatever the intended product, testing helps to reveal the process conditions necessary to consistently produce product to specification.

Under-dried material could present a host of issues depending on the end product; excess moisture would not only inflate shipping costs, but could also promote mold or bacterial growth, making the product unfit for its intended use. Similarly, an over-dried product may be too dusty for acceptance on the market.

The producer may also want to test in order to determine the highest level of moisture they can run through their dryer, since paper waste streams are not always consistent.

In this example, producers are likely to focus on finding the right combination of volumetric fill, retention time, dryer temperature and air volume to consistently reach the target moisture content. Paper producers often find that they must employ a size-reduction step prior to drying in order for the process to be effective.

Concluding remarks

Rotary dryers are essential in processing bulk solids, but maximizing the efficiency of a dryer can be challenging without a thorough testing program. Whether developing a new process, or optimizing an existing one, testing facilities such as the one shown in Figure 3, offer an invaluable opportunity to establish a highly efficient operation.

Testing not only illustrates proof of process and provides other critical assurances, but it also reveals the parameters necessary to reliably yield consistent results, giving producers a leg up on commercializing and refining their operations. ■

Edited by Gerald Ondrey

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Carrie Carlson is a technical writer at FEECO International (same address as above; Email: ccarlson@feeco.com) with more than a decade of experience. She works closely with engineers and process experts to turn complex ideas into easy-to-understand literature.

Reshaping Plastic Waste with Chemical Recycling

The following case study discusses a novel chemical recycling process for converting plastic scrap into valuable material

Sustainability has become one of the main drivers for innovation. Among the critical sustainability issues is the recycling of end-of-use plastics. The diversity of different types of plastics presents problems for mechanical recycling processes, but chemical recycling approaches can offer a pathway to complement mechanical recycling and help turn plastic waste into a resource.

The plastic waste problem

Because plastics are versatile, durable, lightweight and incredibly adaptable, they are used in a wide range of applications in product packaging, housing, automotive and many others. The success of plastics is partly a result of their low cost, but also from their versatility to meet highly demanding functional requirements. Plastics production has significantly increased over the last few decades, both in terms of amount, and also variety. Thousands of different types of plastics with highly specific product attributes have been developed to fulfill different demands.

With this boost in plastic production and diversity, the challenge of disposal has arisen, as plastic durability renders it a serious problem for the environment: end-of-life of plastics contaminate waterways, appear on shorelines and pollute areas on land (Figures 1 and 2). An analysis by the Ellen MacArthur Foundation [*1*] states that roughly one-third of the world's plastic packaging waste ends up in the oceans or in unmanaged dumps on land. From collected plastics, more than 50% is landfilled or incinerated, meaning valuable resources are disposed of in unsustainable ways.

FIGURE 1. The volume and diversity of plastics creates environmental problems for disposal

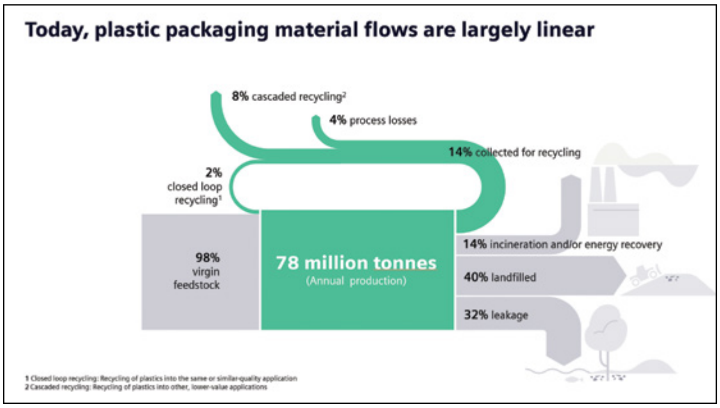

FIGURE 2. The diagram shows how post-use plastics are currently used

Plastic as feedstock

The situation calls for a feedstock change for future plastic production: using recycled oils, biomass or even CO_2, rather than fossil petroleum. Plastic waste has the potential to be a resource, with dedicated procedures for recycling that tackle the global challenges of disposal and benefit the circular economy. Public pressure and government policies can incentivize companies to explore the development of more sustainable recycling solutions with low carbon emissions.

Mechanical recycling of plastics, in which material is ground and regranulated, is an option, but has major limitations. Chief among them lies in the fact that several types of plastics (Table 1) simply do not mix. So the scrap plastic needs to be sorted to serve as input material for new products Mechanical recycling also mainly accepts monolayer plastics, rather than multilayer, which is one of the most common types used in packaging. In addition, most mechanically recycled plastics are downcycled and cannot be used to create food-grade packaging, with the exception of PET (polyethylene terephthalate) bottles.

Novel chemical recycling

For plastic waste that cannot be mechanically recycled, such as films and flexibles, chemical recycling, in which polymer chains are chemically cleaved, can overcome some limitations of mechanical recycling operations.

An example of this is from Plastic Energy, a London-based company that has focused on closed-loop chemical recycling technologies. Plastic Energy has developed a solution that leverages this waste; the company has developed a unique and patented chemical-recycling technology using a thermal anaerobic-conversion (TAC) process to treat plastics that cannot be mechanically recycled.

"The TAC recycling process converts plastic waste into a valuable substance called TACOIL, which serves as a feedstock to produce new plastics, even suitable for food-grade packaging (Plastic2Plastic). TACOIL can be used in petrochemical crackers as a replacement for fossil oils in the manufacturing of virgin-quality plastics, which benefits the circular economy," explains Carlos Monreal, CEO at Plastic Energy.

In Plastic Energy's process, plastics

TABLE 1. COMMON PLASTICS USED IN CONSUMER GOODS AND PACKAGING

Polymer type	Labels (ASTM D7611)	Properties	Typical applications
Polyethylene terephthalate (PET)	01 PET	Clear and resistant to heat, cold, and chemicals	Plastic bottles (water, soft drinks and so on) food packaging film, strapping, carpets, vehicle tyre cords and fibers
High-density polyethylene (HDPE)	02 PE-HE	Low-cost, durable and resistant to shock and cold	Packaging film, industrial film, bottles, tubs, cups, closures, toys, tanks, drums, cable insulation, pipes, gasoline tanks, shipping containers, seating and household goods
Polyvinyl chloride (PVC)	03 PVC	Rigid or soft via plasticizers, resistant to water and solvents and flame retardant	Piping, vinyl flooring, cabling insulation, window frames and roof sheeting
Low-density Polyethylene (LDPE)	04 PE-LD	Lightweight, flexible, low-cost, and resistant to shock and cold	Packaging film, cling-film, bags/sacks, lids, toys, coatings, flexible containers, tubing, irrigation pipes and vehicle dashboards
Polypropylene (PP)	05 PP	lightweight and resistant to heat, water and chemicals	Yogurt pots, snack wrappers, packaging films, bottles/caps, automotive battery cases, parts and body components, electrical components, carpet pile and backing, drainage goods
Polystyrene (PS)	06 PS	Lightweight, structurally weak, and easily thermoformed or expanded	Packaging applications, dairy product containers, cups, coat hangers and electrical appliances
Acrylonitrile butadiene styrene (ABS)	07 O	Durable, stiff, hard and resistant to shock	Computers, televisions, kitchen appliances, toys, musical instruments, electrical products and automobile component parts
Polycarbonates (PC)	07 O	Clear, resistant to shock and heat and flame retardant	Electronic applications, products in construction industry (e.g. for domelights, flat or curved glazing, and sound walls), CDs, Blu-ray discs, automotive, aircraft and railway parts
Polyethers	07 O	Resistant to heat and chemicals and flame retardant	Electrical components, medical equipment and automobile components

are heated in an oxygen-free atmosphere to create hydrocarbon gases, which are then condensed. Working diligently with petrochemical partners, Plastic Energy can create the optimal output that meets the specifications of petrochemical crackers for the manufacture of new plastics. As a result, the virgin-quality recycled polymers created can be used by converters and brands in the same applications as virgin polymers.

Plastic Energy can process multilayer plastics, such as films and flexible packaging, with no need to separate by type or color, making it a complementary approach to mechanical recycling.

With two recycling plants in constant operation in Spain, Plastic Energy has incorporated Siemens automation software and hardware to help ensure the smooth running of its system.

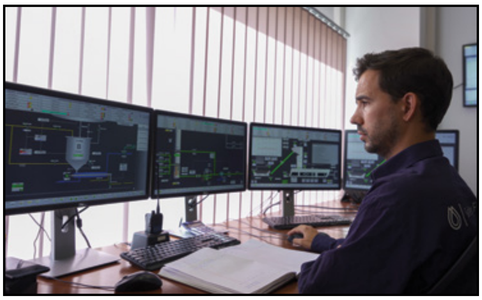

FIGURE 3. Predictive analytics software can pre-empt issues in plastics recycling plants

Automation challenges

Since the TAC reccyling process is a relatively new technology, it is continually evolving, and Plastic Energy is implementing improvements for better efficiencies and product quality. Due to the variable types of plastic feedstock that Plastic Energy accepts, there can be adverse effects on the processing plant. Having predictive analysis done on the process to preempt issues and dealing with them in a timely manner is important to keep the recycling plants running efficiently (Figure 3). Therefore, control strategies have been implemented to make these improvements using Siemens PCS7 capabilities.

Siemens technology is used to give Plastic Energy the flexibility and scalability for its plant designs. Software modules for smart field-device management and maintenance provide the ability to manage plant assets seamlessly to optimize reliability.

There are also instrumentation-related challenges that Plastic Energy has faced over the past several years for unique process conditions. The company is working closely with Siemens to find new solutions to meet process requirements.

With years of experience in processing end-of-life plastic, Plastic Energy's chemical recycling plants are operating at a commercial and industrial scale. The company maintains a technology development roadmap for the next designs to achieve larger scale, better products, lower cost, and lower environmental impact [3].

Chemical recycling is complementary to mechanical recycling, and when used in conjunction, can be an effective and circular way to reduce the impact of plastic leakage into the environment, and prevent plastic waste being sent to landfills or incinerators or exported to developing nations without the proper waste management infrastructure. The technology developed by Plastic Energy, with the incorporation of Siemens automation hard- and software, is being implemented in various facilities all over the world. ■

Edited by Scott Jenkins

Editor's note: The content for this column was originally developed by Martina Walzer, manager of technical concepts at Siemens AG (www.siemens.com), based in Karlsruhe, Germany, and Daniel de Sousa, the engineering manager at Plastic Energy Ltd. (www.plasticenergy.com), based in the U.K.

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1. https://ellenmacarthurfoundation.org/the-new-plastics-economy-rethinking-the-future-of-plastics
2. IChemE Global Awards 2020
3. Plastic Energy Sustainability Report, August 2021

Economic Indicators

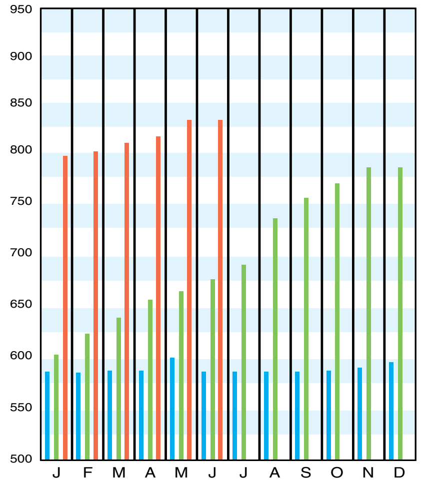
2020 ▬ 2021 ▬ 2022 ▬

Download the CEPCI two weeks sooner at www.chemengonline.com/pci

CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957–59 = 100)	June '22 Prelim.	May '22 Final	June '21 Final
CE Index	833.1	831.1	701.4
Equipment	1,059.1	1,056.4	868.9
Heat exchangers & tanks	897.9	898.9	745.0
Process machinery	1,074.7	1,075.3	876.6
Pipe, valves & fittings	1,496.7	1,494.7	1,195.9
Process instruments	571.5	575.0	521.9
Pumps & compressors	1,285.8	1,273.3	1,125.8
Electrical equipment	768.0	756.6	609.8
Structural supports & misc.	1,190.3	1,177.7	940.0
Construction labor	356.3	354.3	341.9
Buildings	840.9	847.4	763.8
Engineering & supervision	312.8	311.5	310.6

Annual Index:
2014 = 576.1
2015 = 556.8
2016 = 541.7
2017 = 567.5
2018 = 603.1
2019 = 607.5
2020 = 596.2
2021 = 708.0

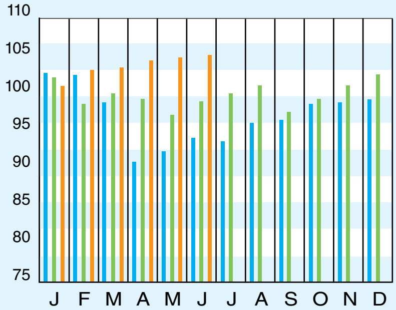


Starting in April 2007, several data series for labor and compressors were converted to accommodate series IDs discontinued by the U.S. Bureau of Labor Statistics (BLS). Starting in March 2018, the data series for chemical industry special machinery was replaced because the series was discontinued by BLS (see *Chem. Eng.*, April 2018, p. 76–77.)

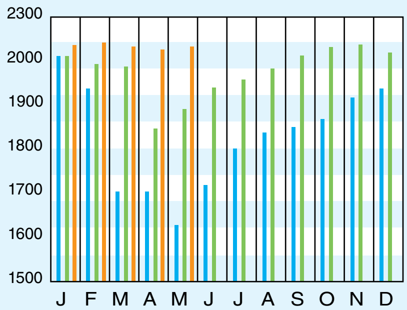
CURRENT BUSINESS INDICATORS

	LATEST	PREVIOUS		YEAR AGO
CPI output index (2017 = 100)	Jun. '22 = 101.4	May '22 = 102.1	Apr. '22 = 101.6	Jun. '21 = 99.1
CPI value of output, $ billions	May '22 = 2,183.0	Apr. '22 = 2,105.2	Mar. '22 = 2,088.1	May '21 = 1,747.7
CPI operating rate, %	Jun. '22 = 82.2	May '22 = 82.7	Apr. '22 = 82.4	Jun. '21 = 80.2
Producer prices, industrial chemicals (1982 = 100)	Jun. '22 = 372.4	May '22 = 368.8	Apr. '22 = 358.8	Jun. '21 = 317.0
Industrial Production in Manufacturing (2017 =100)*	Jun. '22 = 101.6	May '22 = 102.2	Apr. '22 = 102.7	Jun. '21 = 98.1
Hourly earnings index, chemical & allied products (1992 = 100)	Jun. '22 = 198.6	May '22 = 198.9	Apr. '22 = 196.7	Jun. '21 = 195.0
Productivity index, chemicals & allied products (1992 = 100)	Jun. '22 = 93.0	May '22 = 93.1	Apr. '22 = 94.8	Jun. '21 = 96.0

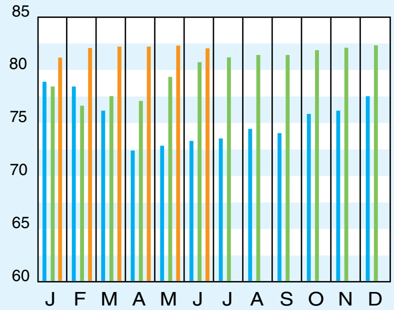
CPI OUTPUT INDEX (2017 = 100)†



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2012 to 2017
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

CURRENT TRENDS

The preliminary value for the *CE* Plant Cost Index (CEPCI; top) for June 2022 (most recent available) edged higher than the previous month's value, continuing the upward trend of the last 18 months, although at a slower pace. In June, small upticks were observed in the Equipment, Construction Labor and Engineering & Supervision subindices, while the Buildings subindex fell. The current CEPCI value now sits at 18.8% higher than the corresponding value from June 2021. Meanwhile, the Current Business Indicators (middle) show decreases in the CPI output index and the CPI operating rate for June 2022, and a small increase in the CPI value of output for May 2022.